SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1899.

GENERAL PHYSICS.

1111. *Viscosity of Supercooled Liquids.* **G. Tammann.** (Zeitschr. Phys. Chem. 28. pp. 17–32, 1899.)—The author determines the viscosities of supercooled grape sugar, cane sugar, brucine, piperine, papaverine, and other organic substances. In the neighbourhood of the freezing-point the viscosity increases at a normal rate; but at an average of 90° (the actual numbers vary considerably) below the respective freezing-points it begins to increase at a very rapid rate. In the case of betol, experiment shows that there is no change in volume corresponding to the remarkably large change in viscosity; presumably the same applies to the other cases. A. Gs.

1112. *Optical Measurement of Length.* **C. Fabry, J. M. de Lépinay, and A. Perot.** (Comptes Rendus, 128. pp. 1317–1319, 1899.)—The solid to be measured is placed between two planes of silvered glass, A′ A′, so that the faces *a*, *a*′ of the solid are parallel to the planes. Then the thickness of air between A and A′ is the sum of the thickness of the solid and of the two layers of air *a*A and *a*′A′ contained between the solid and the glass planes. The upper part of the space between A and A′ is free, and can be measured by an interference method already described. The small intervals *a*A and *a*A′ are also measured by interference fringes with the aid of test plates and strong monochromatic rays derived from a mercury arc. The main condition of accuracy, viz., the perfect parallelism between the silvered planes, is easily verified by the appearance of the fringes. The whole of the adjustment and measurement may be accomplished in a few seconds, so that fluctuations of temperature do not seriously affect them. The results attained are very accurate, the error not exceeding 0·1 μ in a measured length of 4 cm. E. E. F.

1113. *Measurement of Liquid Volumes.* **J. Wagner.** (Zeitschr. Phys. Chem. 28. pp. 193–219, 1899.)—A minute investigation of the sources of error attending the measurement of liquids and the use of standard solutions. The degree of accuracy attainable with pipettes, measuring flasks, and burettes is considered with reference to the mode of emptying, the time of outflow, changes in temperature, errors of graduations, &c. Errors in weighing and the reduction of weighings to a vacuum are also dealt with. Stress is laid on the necessity of removing all dirt and grease from the surface of measuring vessels if exact results are to be obtained; a mixture of concentrated sulphuric acid with potassium bichromate is one of the best cleansing agents. The delivery of pipettes is in general best completed by blowing out the last portions of liquid. The amount of liquid left adhering to the walls of the pipette varies with different liquids, but in the case of ordinary aqueous solutions these differences may safely be neglected. When using measuring flasks the portion of the neck above the liquid should be carefully dried, and the final adjustment to the mark effected by means of a capillary pipette. Burettes may be read to within 0·01 cc., but the errors of graduation, even with the best instruments, are almost always such as to necessitate careful calibration and the construction of a table of corrections. At least 40–45 seconds should be allowed to elapse before the burette is read, so as to allow of the draining of the liquid down the sides of the tube. Neglect of alterations in temperature may lead to considerable errors, since a change from 15° to 25° increases the volume, and diminishes the concentration, of ordinary normal solutions to the extent of 0·2–0·3 per cent. A table of corrections for temperature is given. It is suggested that a temperature of 20° would be much more generally useful and convenient than 15° as a standard temperature for the graduation and verification of graduated vessels. The importance of purity in the reagents used in preparing solutions is insisted on, and illustrations are given of the small value to be attached to the usual commercial guarantees of purity. N. L.

1114. *Instrument-Reading.* **F. G. Baum.** (Phys. Rev. 8. pp. 181–183, 1899.)—The paper gives a mathematical account of a general method for determining the best reading of an instrument for least error in measuring a given quantity. If y is the quantity to be measured, and x the observed quantity, and if y equals $f(x)$, then the best reading is given by the equation

$$f(x)\,.\,f''(x)=[f'(x)]^2$$

A. Gs.

1115. *Aneroid Barometers.* **C. Chree.** (Phil. Trans. 191. pp. 441–499, 1898.)—The paper contains accounts of careful experiments with aneroid barometers. The author studied the elastic after-effect, the effects of temperature, secular changes, &c. Curves and empirical formulæ generalise the results attained

A. Gs.

1116. *Stroboscopic Determination of Speed, Frequency, and Lag.* **G. Benischke.** (Elektrotechn. Ztschr. 20. pp. 142–147, 1899.)—The speed of fan motors is determined by means of another motor, the shaft of which carries a counting mechanism and a stroboscopic disc, through which the fan is viewed.

To determine frequencies, the current whose frequency is to be determined is passed through an electromagnet, and the field of this magnet is allowed to act on an iron rod supporting a flask of water having a tap from which a thin stream can flow. The alternating magnetic field causes the iron rod to vibrate, and the stream of water to be broken up into a series of drops corresponding in number to the alternations. The number falling in unit time can be determined stroboscopically by means of a rotating slotted disc.

To determine lag, the light from an alternate current arc (which fluctuates with the alternations) is observed through a rotating slotted disc driven by an alternate current motor supplied by the same current as the arc. If the motor runs synchronously the disc appears to stand still; if there is a lag, the image will rotate, and the number of spokes passing a given point per minute will give the number of revolutions by which the motor falls below the speed of synchronism.

C. K. F.

1117. *Harmonic Motion.* **C. Barus.** (Science, 9. pp. 385–405, 1899.)—After a summary of the requirements of the ideal apparatus to illustrate wave motion under different possible circumstances, the author describes a wave machine he has constructed to fulfil these conditions.

The vertical oscillations of the "particals," which are represented by small balls riding on the ends of horizontal levers, are produced by means of two systems of lifting cams, borne by two axes lying parallel to the direction of propagation. In this way composition of waves may be introduced. A limb attached at right angles to each lever can, when desired, by pressing on one set of cams, introduce a horizontal component in the oscillations. Provision is made for inserting various systems of cams of different successive angular displacements, as well as for different relative rates of revolution of the axes.

The paper gives full particulars of how, by these simple means, the various kinds of wave propagation may be illustrated.

F. T. T.

1118. *Period and Logarithmic Decrement of a Continuously Vibrating Wire.* **J. O. Thompson.** (Phys. Rev. 8. pp. 141–151, 1899.)—Experiments performed at Glasgow in 1864–5 made it appear probable that a wire kept for a long time in constant torsional vibration exhibited an increased period and an increased logarithmic decrement. The present paper describes elaborate experiments undertaken to test this conclusion. The torsional pendulum was arranged in a basement chamber, whose temperature suffered a change of only about half a degree in the twenty-four hours. The amplitude was maintained constant by an automatic electromagnetic arrangement when testing the constancy of the period.

The wire was of copper, 37·7 cm. long. and 0·081 cm. in diameter. The arc was 180°. The figures for the period incline the author to the belief that the period changes with the temperature, not instantly, but in a somewhat sluggish manner. In one experiment with a copper wire the period, after fifty hours of continuous vibration through an average arc of 180°, was found to be just what it was in the first two minutes. Gauss's method of timing was used, and the degree of accuracy aimed at and attained was about $\frac{1}{2000}$. To test the logarithmic decrement, two silvered mirrors were mounted back to back, so that their edges were towards the scale when the pendulum was at rest. A double amplitude of vibration of about 180° was then used, so as to give, at each turning-point, readings near the centre of the scale. The total arc was allowed to fall from about 185° to 175°. The electrical driving device was then used to bring the amplitude up to its original value. In keeping the wire in continuous vibration through an average arc of 180° for fifty consecutive hours the results show that the logarithmic decrement varied between 0·00370 to 0·00358; the temperature varied through 2·7°.

Other experiments showed that, by suitably modifying the antecedent amplitude of vibration *any decrement within wide limits*, and *any period within narrow limits* might be obtained. The author concludes that in any vibrating wire not unduly loaded, when temperature and amplitude of vibration are constant, both the period and logarithmic decrements are constant quantities. E. H. B.

1119. *Continuity of Wave Motion.* **Kelvin.** (Phil. Mag. 46. pp. 494–500, 1898.)—Imagine a rigid globe of platinum 12 cm. in diameter hung inside a rigid massless spherical shell of 13 cm. internal diameter. Let the shell and nucleus be made to oscillate in opposite directions with simple harmonic motion. Then, in air, we have, for suitable frequencies, a range of audible sounds; by increasing the frequency we get homogeneous polarised light. If the apparatus is imbedded in an elastic solid, and made to vibrate as before, then for moderate frequencies (10^6 or even higher) two sets of waves are propagated with different velocities, each independent of the frequency. Raising the frequency to values corresponding to radiant heat, visible light, or ultra-violet light, the question is, what becomes of the condensational-rarefactional waves, and what is the nature of the transition of the velocity of propagation of the distortional waves from 3 kilom. per second to 200,000 kilom. per second (the medium being glass)? "Is it probable (if ether is absolutely incompressible it is certainly possible) that the condensational-rarefactional wave becomes less and less with frequencies of from 10^6 to 4×10^{12}, and that there is absolutely none of it for periodic disturbances of frequencies from 4×10^{12} to 3000×10^{12}?"

Again, let the shell be deeply imbedded in, and firmly attached to, a very large homogeneous elastic solid, and let the shell and nucleus make rotational oscillations (in virtue of a mutual forcive) about a common axis. Purely distortional waves will be propagated. For a small frequency, at distances of hundreds of kilometres, the wave-length will be (in glass or iron) approximately 3 kilometres; for frequency 1000 it will be about 3 metres at distances of hundreds of metres; for frequency 10^6 it will be 3 millim. throughout the medium, except close to the shell. For a frequency such as 100×10^{12} "it is probable that no distortional wave of motion of the ponderable matter can be transmitted outwards; but it seems quite certain that distortional waves of radiant heat in ether will be produced close to the boundary of the shell, although it is also probable that if the surrounding solid is either glass or iron, these waves will not be transmitted far outwards, but will be absorbed, that is to say converted into non-undulatory thermal motions, within a few mikroms of their origin."

To obtain an electrical analogy the shell must be replaced by a rigid, infinitely massive shell of glass or other non-conductor, and the nucleus by a massless non-conducting globe electrified with a given quantity of electricity. The apparatus being supposed surrounded by air or ether, vibrations to and fro with moderate frequencies give a periodic variation of electrostatic force in the medium, the phase nearly agreeing with that of the vibrator. High frequencies (such as 100×10^{12}) give polarised light. Rotational oscillations, for moderate frequencies, give no alteration of the electrostatic force and no perceptible magnetic force: high frequencies will give polarised light. "The same result would be obtained by taking simply a fixed solid non-conducting globe and laying on wire on its surface approximately along the circumferences of equidistant circles of latitude, and, by the use of a distant source, sending an alternate current through this wire. In this case, while there is no manifestation of electrostatic force, there is strong alternating magnetic force, which in the space outside the globe is as if from an ideal infinitesimal magnet with alternating magnetisation, placed at the centre of the globe and with its magnetic axis in our axial line." G. B. M

1120. *Production of Waves in an Elastic Solid.* **Kelvin.** (Phil. Mag. 47. pp. 480–493, 1899.)—The author considers the application of the force within a limited space required to produce spherical solitary waves, or trains of periodic waves, of both species, equivoluminal and irrotational. By equivoluminal it is understood that every part of the solid keeps its volume unchanged during the motion. Referring to Stokes' paper on the Dynamical Theory of Diffraction (Stokes' Mathematical Papers, vol. 2, p. 243) he gives the equation of motion, as in his former papers, in terms of ξ, η, ζ, the displacements at any point in the solid, and gives an answer to the question as to what the forcive must be, applied to the boundary of a hollow S of any shape in the solid, when the strain of the matter in contact with S′ is given. Then he confines himself to the case in which S′ is spherical, and the motions and forces are in meridional planes through a diameter OX.

He finds the complete solution of the equations of motion in the form $\xi=\xi_1+\xi_2$, &c., in which ξ_1 belongs to the equivoluminal wave propagated with velocity u, and ξ_2 to the irrotational wave with velocity v, each wave being capable of existing without the other. Hence he finds the most general irrotational solution and the most general equivoluminal solution, and discusses the general result. S. H. B.

1121. *Transformation of Central Motions.* **P. Stäckel.** (Göttingen Nachrichten, 2. pp. 157–165, 1898.)—(1) The author describes Boltzmann's transformation. Boltzmann had shown that if a particle describes a curve under a central force $f(r)$, with k for area constant, *i.e.*, the area described in unit time by the radius vector r, then another particle under a force $f_1(r)$ may describe a curve in which r is the same function of the time as in the former case, with k_1 for area constant, provided that

$$f_1(r)-f(r)=\frac{k^2-k_1^2}{r^3}$$

(2) The author then considers the case of a particle moving on a surface of revolution under a force directed towards the axis, and he shows that Boltzmann's transformation is a particular case of this problem.

(3) Finally he discusses the general problem of transformation of motions, considering the curves which belong respectively to two related "Mannigfaltigkeiten" M_n and m_n. S. H. B.

1122. *Deformation and Sliding in Calcareous Spar.* **W. Voigt.** (Göttingen Nachrichten, 2. pp. 146–153, 1898.)—The author discusses experiments in which a rectangular parallelopiped of calcareous spar, suitably orientated with respect to the crystallo-

graphic axis, was subjected to gradually increasing pressures until sliding commenced between the layers. He draws the conclusion that the sliding depends not, or not only, on the geometrical configuration of the sliding layer, but on a process which goes on within the molecules of the substance. This theory he would extend to all deformations which take place in solid bodies—and he considers that a theory of elasticity founded on the assumption of the molecules being rigid or unchangeable bodies can be no more than an approximation. Also he regards this as an argument in favour of his own view. (Gött. Nachrichten, 1893, No. 16, p. 669) of the nature of Piëzo-electricity and Thermo-electricity.
S. H. B.

1123. *Exploring-Balloons.* **A. Bouquet de la Grye.** (Ann. du Bureau des Longitudes A1–A14, 1899.)—An interesting *résumé*. Greatest height attained, 18,450 metres, Tempelhof military balloon park; temperature observed, − 68° C. Greatest theoretical height for practicable balloon, with instruments, about 20,000 metres, or about 23,000 metres in sunshine. Greatest height reached by aeronaut (inhaling oxygen), M. Berson, 9,156 metres. It is of advantage not to fill the balloon completely before it is launched, but to allow for expansion under the diminished pressure above. The height attained can be regulated by supplementary weights. The drift at high altitudes is generally towards the N.E., whatever the wind below. At 15,000 metres there is a difference of 50° C. between the sunshine and the shade. Kites at 4,000 metres provide controls for the instrumental observations. Altitudes may also be measured by the angle of view on photographic plates.
A. D.

1124. *Modern Geodesy in France.* **Bassot.** (Ann. du Bureau des Longitudes, B1–B34, 1899.)—A very interesting summary of the work done in revising the triangulation and connecting the surveys of France, Spain, and Algeria, and of the work to be done for the new map of France and the survey of the French colonies. Subsidiary work in measuring the local force of gravity is also described.
A. D.

1125. *Gravity on Mont Blanc.* **P. Pizzetti.** (Roma R. Accad. Lincei Atti, 8 pp. 34–38 and 65–68, 1899.)—A mathematical paper. The attraction of Mont Blanc, after allowing for snow and ice, is less than the calculated value by an amount corresponding to an ideal indefinite horizontal cavity of about 1,000 metres in height: 250 metres, apparently, from measurements at Chamounix.
A. D.

1126. *Meteorological Observations at Göttingen.* **J. Kümmell.** (Göttingen Nachrichten, 3. pp. 223–259, 1898.)—The paper is compiled on the plan of the climate of Frankfurt-on-the-Main by J. Ziegler and W. König and covers the period 1887 to 1896, Hugo Meyer having already published statistics on the years 1857 to 1881. The data for 1881 to 1887 were incomplete. Göttingen is a second-class meteorological observatory, situated 150 m. above sea-level, in lat. 51° 32′ and long. 9° 56′ E. When the barometric means observed, 747·8 mm. annual, 749·6 for January, 747·0 for July are reduced, the figures remain 1·0 mm. (annual mean), or 2·4 mm. (January) higher than those corresponding to Ferrel's averages for that latitude. Some of the extremes are striking (768·6 mm. on January 29, 1896, and 719·8 on February 9, 1889, and the sharp fall in the barometric curve in March; the falls in September and in June are less marked). Owing to the prevalence of S.W. winds and the (local) protection against E. winds, the temperature is higher than the average for that latitude by 9° according to Hann, by 4·6° according to Spitaler. On the other hand, the period 1887 to 1896 has been cooler (annual difference 0·3, January 1, 1·7) than the period 1857 to 1881. This applies also to Bremen and Frankfurt-on-the-Main, and probably to Central Europe in general; the absolute humidity curves of the two periods show the same relations. Attention is drawn to pentades, periods of five days, to temperature relapses, and to the apex values of the various months. As regards rain, the popular rule seems to hold that a low barometer signifies rainy weather. H. B.

LIGHT.

1127. *Methven Standard with Blackened Chimney.* **R. A. Fessenden.** (Elect. World, 33. p. 231, 1899.)—The author points out the error produced by blackening the back of the chimney round the standard flame. The argument in favour of blackening the back of the chimney is as follows: A certain amount of light is reflected from the back of the chimney and thrown forward through the Methven slot, thus making more light pass through the slot. It is, however, obvious that if the back of the chimney throws by reflection extra light through the slot, the same amount is thrown away from the slot by the reflection of the front of the chimney, so that the presence of a glass chimney, if symmetrical round the flame, does not increase the amount of light passing through the slot. As a matter of fact it slightly reduces it, for two reasons: first, on account of the absorption of the glass; second, because some of the reflected light is thrown out at the ends of the chimney.

E. C. R.

1128. *Candle-Power of Glow Lamps.* **R. A. Fessenden.** (Elect. World, 33. p. 230, 1899.)—The author measures the mean horizontal candle-power and divides it by the mean spherical candle-power: this ratio, expressed as a percentage, he calls the distribution factor. This varies from 72 to 84 in a number of experiments made. In general, the longer the filament of a given type of lamp the greater the distribution factor. In other words, a comparatively low resistance carbon should be used where uniform distribution is wished. Also, contrary to what was expected, there is practically little difference between horseshoe and looped filaments, as met with in the market, so far as distribution is concerned, the average factor being 76 for looped filaments 8½ inches long, and 78 for horseshoe filaments 6 inches long.

E. C. R.

1129. *Light at Low Temperatures.* **A.** and **L. Lumière.** (Comptes Rendus, 128. pp. 359–361, 1899.)—Ultra-sensitive gelatino-bromide photo-plates, cooled to − 191° C. (liquid air), require from 350 to 400 times as long an exposure to light to produce a given effect as is required at ordinary temperatures: most of the sensitive photographic preparations are not acted upon at all. The plates are not permanently altered at all by the cooling, neither is any latent image, existing within their film. The cooling is the only cause of the temporary deprivation of sensitiveness; and the production of the latent image appears to be due to chemical action. Substances made to phosphoresce by light have their phosphorescence extinguished by immersion in liquid air, to be fully regained as the temperature is restored. A. D.

1130. *Singular Points in Optical Systems.* **P. Lefevre.** (Comptes Rendus, 128. pp. 1320–1322, 1899.)—There are several interesting relations between the "poles" of an optical system as defined by the author and Bravais' points. For instance: a circumference or straight line passing through Bravais' points, and another circumference or straight line passing through two poles and situated in the same plane, intersect at right angles. Also: the distance of any point on the axis from the line joining the poles is the arithmetic mean of its distances from Bravais' points. The relations discovered may be immediately applied to thick lenses and mirrors. E. E. F.

1131. *Paris Exhibition Siderostat.* **P. Gautier.** (Ann. du Bureau des Longitudes, C1–C26, 1899.)—An account of this instrument, with drawings and details as to manufacture, particularly of the mirror. The focal length is 60 metres and the aperture of the objective 125 cm. The arrangement renders the ocular part independent of the apparent movement of the sky, enables stars to be either observed or photographed, and provides the ocular with movements in right ascension and declination. The mirror is 2 metres in diameter. A. D.

1132. *Apparent Colour.* **W. B. Lane.** (Canad. Instit. Trans. 5. pp. 225–241, 1898.)—This is a preliminary paper in which the author deals with the modifications produced in the apparent colour of objects by change of the observer's distance. Previous work on this subject is referred to, and the author leaves over for a future paper an account of his later observations with more accurate apparatus. Some of the results obtained appear to contradict Hering's theory of colour. J. J. S.

1133. *Transmission of Light by Turbid Media.* **P. Compan.** (Comptes Rendus, 128. pp. 1226–1229, 1899.)—If a radiation of intensity I_0 traverses a turbid medium of thickness z, its intensity I after transmission is given by the formula

$$I = I_0 e^{-kz}$$

According to Clausius, $k = m/\lambda^2$, where λ is the wave-length and m a constant. According to Stokes, $k = m/\lambda^4$.

The author has experimented upon lampblack, silver chloride, magnesia, barium sulphate, and other bodies to discriminate between these formulæ. He finds that neither of them strictly applies, and that the transmission depends upon an additional factor, viz., the size of the disturbing molecule. E. E. F.

1134. *Total Reflection.* **E. Ketteler.** (Wied. Annalen, 67. 4. pp. 879–893, 1899.)—The "glancing ray" which, according to Voigt, penetrates into the second medium in so-called total reflection must, according to the author, be explained on principles different from those given. The author shows that if the media are transparent, the energy of the "glancing ray" per unit of time is zero, and therefore the totally reflected ray has the same energy as the incident ray. During half the time the momentary energy of the incident wave exceeds that of the reflected wave, and energy is transferred to the ether of the second medium. But during the other half of the time the same amount of energy is withdrawn again. The net result is that though there is a wave motion at the boundary of the two media, no train of waves is propagated into the second medium. The equations for absorbing media are of the same form, and the conclusion is similar.

The author proceeds to work out simplified equations for absorbing media, and applies them to the theory of metallic reflection. E. E. F.

1135. *Optical Characteristics of Garnet.* **C. Klein.** (Berlin Akad. Sitzber. 44. pp. 676–692, 1898.)—A mineralogical paper, in which the investigations of the author as well as those of other observers into the optical anomalies of the various forms of garnet are considered. J. J. S.

1136. *Refractive Indices of Chloride Solutions.* **J. Conroy.** (Roy. Soc. Proc. 64. pp. 308–318, 1899.)—An account is given of observations of the refractive indices and densities of normal and semi-normal aqueous solutions of hydrogen chloride and the chlorides of the alkalis at a uniform temperature of 18°. The results are set forth in a table in which the indices are given to six places of decimals and the densities to five places. A second table gives the results corrected for small errors in the strengths of the solutions. It appears that both the densities and the refractive indices increase with the molecular weight of the substance in solution, except in the case of the refractive index of potassium chloride, which is slightly lower than that of sodium chloride. In other tables are given the weight of water contained in 1000 cc. of each of the solutions, and the differences between the refractive indices of the solutions and the refractive index of water under ordinary conditions.

The method employed was the ordinary hollow prism one, special care being taken to keep the solution at 18°, or within one- or two-tenths of a degree of 18°. An alteration of 1° in the temperature of water at about 20° makes a difference in the refractive index of nearly one unit in the fourth decimal place.

J. J. S.

1137. *Theory of the Microscope.* **K. Strehl.** (Zeitschr. Instrumentenk. 18. pp. 301–317, 1898.)—Referring to Abbe's papers on this subject, and also to the recent ones of Rayleigh and Wright, the author enters into various calculations with reference to the formation of images in the microscope. He includes in his discussion chromatic aberration, astigmatism, and spherical aberration, basing his work chiefly on the formulæ for the theory of the telescope.

J. J. S.

1138. *Constant of Emission Function Photometrically Determined.* **F. Paschen** and **H. Wanner.** (Berlin Akad. Sitzber. 2. pp. 5–11, 1899.)—According to the theory of W. Wien the radiation intensity of an "absolutely black body" has the form

$$J = c_1 \lambda^{-5} e^{-c_2/\lambda T} \qquad (1)$$

where J is the intensity of radiation of wave-length λ at the absolute temperature T. The truth of this expression was rendered probable by experiments by Paschen, and the object of the present work was to determine c_2. Equation (1) may be put in the form

$$\log_{10} J = r_1 - r_2/T, \qquad (2)$$

where

$$r_1 = \log_{10} (c_1 \lambda^{-5}),$$

and

$$r_2 = \frac{c_2}{\lambda} \log_{10} e.$$

A curve, called the *Isochromatic Line*, may then be plotted, having values of 1/T as abscissæ and the corresponding values of $\log_{10} J$ as ordinates. The slope of this line gives r_2, and thus c_2 as required.

The experimental determination was carried out by means of a König's Spectro-Photometer. As the best approach to an "absolutely black body," a surface blackened with iron oxide was used. Tables of results for four different wave-lengths and for various temperatures are given. The Isochromatic Lines are plotted for three of these wave-lengths, and are, in each case, straight lines. The values found for c_2 are as follows:—

	μ	μ	μ	μ
$\lambda=$	0·6678	0·5893	0·5016	0·4861
c_2	14322	14489	14467	14473

Mean value of $c_2 = 14440$ [$\mu \times$ absolute temperature].

E. H. B.

1139. *Magneto-Optic Phenomena.* **J. G. Leathem.** (Cambridge Phil. Soc. Trans. 17. pp. 16–40, 1898.)—Leathem refers to Fitzgerald's investigations on the electromagnetic theory of the reflexion and refraction of light (Phil. Trans. 1880), and to Larmor's modification of them in his report on the action of magnetism on light (Brit. Assoc. 1893). Larmor introduces into the equations as given by Fitzgerald the Lagrangian indeterminate multiplier λ, which satisfies the condition $\nabla^2\lambda=0$, and so appears as the potential of a distribution over the interface of two media, at which reflexion takes place. It may be interpreted as an irrotational or pressural wave propagated along the interface. In the present paper Leathem uses the Principle of Least Action and introduces a Dissipation Function to obtain from the above hypothesis the equations of propagation in a conducting medium and the boundary conditions at an interface of two such media. These are applied to the solution of the problem of reflexion of light from a magnet and the results compared with experiments of Kerr, Sissingh, and Zeeman. Leathem arrives at the conclusion that the theory considered does not satisfactorily explain the observed facts. S. H. B.

1140. *Magneto-Optic Theory.* **W. Voigt.** (Wied. Annalen, 67. 2. pp. 345–365, 1899.)—The author attempts to frame a complete theory of the magneto-optic effects by amplifying the equations governing selective absorption. It is based upon Drude's Hertzian equations. He succeeds in explaining some apparent anomalies, and his formulæ are corroborated by the results recently obtained by Becquerel. E. E. F.

1141. *Rotatory Polarisation of Malic Acid.* **L. Kann.** (Wien Akad. Sitzber. 107. pp. 681–705, 1898.)—A record is given of an extensive set of observations on the rotatory polarisation exhibited by solutions of malic acid of various concentrations. The measurements were made with a Lippich's half-shadow polarimeter and the temperature varied from about 10° to 100° C. The results obtained are embodied in fourteen tables, and the effect of change of temperature is clearly shown in the curves given by the author, which also indicate the anomalous dispersion which occurs with certain concentrations and temperatures. J. J. S.

1142. *Magnetic Polarisation of Quartz.* **A. Borel.** (Comptes Rendus, 128. pp. 1095–1097, 1899.)—The magnetic rotatory polarisation of quartz, discovered by Becquerel, is difficult to study, on account of the natural rotational power which that mineral possesses without any magnetic field. The author has, however, succeeded, by employing a combination of right-handed and left-handed quartzes, 6 cm. thick, which, together, produce no optical rotation. He studied the rotation of a few lines, chiefly cadmium lines, which extend from the red far into the ultra-violet. He used the ordinary polarimeters of Laurent, Summer, and Wild, but for the ultra-violet measurements he employed the fluorescent eye-piece devised by Soret. He thus determined Verdet's constant for eight spectrum lines. This constant increases with the refrangibility of the rays. It is 0·01684 for the D line of sodium and 0·16032 for the 25th (ultra-violet) cadmium line, whose wave-length is 319·39 $\mu\mu$. The rotation increases with the temperature, at a rate which increases with the refrangibility. E. E. F.

1143. *Spectra.* **A Pérot** and **C. Fabry.** (Comptes Rendus, 128. pp. 1221–1223, 1899.)—The number and intensity of lines in electric spark spectra depends largely upon the manner of excitation of the vacuum tube. No direct influence of the excitation upon the wave-length of the lines has hitherto been observed, but often an apparent displacement occurs due to the emphasising of a certain portion of a group of lines in close proximity at the expense of another portion. For various physical purposes it is important to have spectrum lines as bright and as sharply defined as possible. The authors have determined the conditions most suitable for these requirements. The best results were obtained by inserting the tube in a continuous-current circuit having a difference of potential of at least 700 to 800 volts. This was done by means of a battery of 500 small accumulators of 0·4 ampere-hour capacity. Such a battery is capable of maintaining the tube in action for a very long time, since the current required by the tube is not more than 3 or 4 milliamperes. The rays attained are of extreme fineness. Thus the coincidence of the fringes furnished by the green and the red rays of cadmium could still be observed with a difference of path amounting to 18 cm., which permits the optical measurement of thicknesses up to 9 cm. E. E. F.

1144. *Chemical Action of Röntgen Rays.* **P. Villard.** (Comptes Rendus, 128. pp. 237–239, 1899.)—Gelatino-bromide photo-plates fully acted upon by Röntgen rays are regenerated by light, say a large Welsbach burner at 40 cm. for 50 seconds, with the exception that the plate is no longer sensitive to light. The region of the spectrum most active in this sense is precisely that which acts most powerfully upon the photo-plate, being most absorbed by it; but there are also other regions of maximum activity in minor degree, which vary with the plates made use of. After being subjected to Röntgen rays the plates become in this way sensitive to the reversing effect of rays of such low refrangibility that they can pass through three thicknesses of black paper, and a positive of that part of the spectrum is produced. If sufficient time of exposure be allowed, the reversing effect is visible without development of the plate. A Röntgenised photo-plate given a long exposure in the camera (30 secs.) gives on development a positive image of the object. A. D.

1145. *Fluorescent Solid Solutions.* **J. R. Mourelo.** (Comptes Rendus, 128. pp. 1239–1241, 1899.)—The author has experimented with a variety of solid solutions of manganese carbonate in strontium sulphide in order to determine the composition giving the greatest intensity of fluorescence. The best results were obtained with a mixture of strontium carbonate 100 grammes, flowers of sulphur 33 gr., sodium carbonate 1·4 gr., fused sodium chloride 0·85 gr., manganese carbonate 0·15 gr. This mixture was finely powdered, compressed, and placed in an earthenware crucible. It was kept at a red heat for three hours, and was then allowed to cool slowly. The result was a hard, compact, greyish-white mass of scoriated appearance. Exposed to daylight, it showed a brilliant green fluorescence. The colour is brighter and purer than that obtained with bismuth nitrate in the place of manganese carbonate. A good fluorescence may also be obtained by heating together 100 parts strontium carbonate, 33 parts flowers of sulphur, and 0·15 part manganese carbonate. After a few seconds of exposure to daylight it shows a fine and persistent green fluorescence, without blue or yellow light. It is possible that other fluorescent substances may be prepared in a similar manner, and in this connection it must be remembered that Boisbaudran obtained fluorescence of various solid solutions of manganese sulphate by exposing them to an electric brush discharge. E. E. F.

HEAT.

1146. *Thermal-Conductivity of Liquids.* **E. van Aubel.** (Zeitschr. Phys. Chem. 28. pp. 336–341, 1899.)—Lees' results are tabulated against those of H. F. Weber and Graetz, and the want of agreement, especially as regards the variation with temperature, is pointed out. Weber's law, that the diffusivity of a liquid per unit density, or $k/c\rho$, is inversely proportional to the mean distance between its molecules, or $\sqrt[3]{(m/\rho)}$, is then examined and found to be wanting. R. E. B.

1147. *Pressure and Thermal Conductivity.* **C. H. Lees.** (Mem. Manchester Lit. and Phil. Soc. 43. 8. pp. 1–6, 1899.)—Slices of substances from $\frac{1}{8}$ to 2 cm. thick were submitted to pressures up to $54\frac{1}{3}$ atmospheres, being squeezed in a hydraulic press between steel discs, one of which was uniformly heated by electrical means and the other cooled by a continuous flow of water. Contact between the discs and slices was ensured by layers of glycerine. No change of conductivity with pressure was found within the experimental limits in the cases of granite and marble, but a slight increase in the cases of glass and ebonite and an increase of 4 or 5 per cent. in the case of soft sandstone were observed. The experiments are to be repeated with mercury substituted for glycerine. R. E. B.

1148. *Measurement of Thermal Conductivity.* **C. H. Lees.** (Phil. Trans. 191. pp. 399–440, 1898.)—The materials to be tested in the case of solids are cut into discs of 4 cm. diameter and of various thicknesses. On one side of the disc to be tested is placed a copper disc of the same diameter and on the other side a compound disc, consisting of two copper discs enclosing between them a flat heating coil of silk-covered platinoid wire, also of the same diameter. At opposite extremities of a diameter of each copper disc are bored radial holes, into which are respectively soldered a platinoid and copper wire to form a thermojunction. The whole is enclosed in an air bath which can be kept at any required temperature by a coil of insulated platinoid wire wound outside it. The temperature differences between the discs are measured by balancing the E.M.F. of the thermojunctions against a known potential difference on a potentiometer.

In the case of liquids the arrangement is somewhat modified.

The paper gives full descriptions of the apparatus, and precautions employed, theory of the methods, and the results of experiments with a number of solids, liquids, and mixtures of liquids which are thus summarised :—

1. Solids which are not very good conductors of heat, in general decrease in conductivity with increase of temperature in the neighbourhood of 40° C. Glass is an exception to this rule.

2. Liquids in the neighbourhood of 30° C. follow the same law.

3. The conductivity of a substance does not invariably change abruptly at the melting-point.

4. The thermal conductivity of a mixture lies between the conductivities of its constituents, and seems to be connected with the constitution and conductivities by a simple law.

5. Mixtures of liquids decrease in conductivity with increase of temperature in the neighbourhood of 30° C. at about the same rate as their constituents. E. C. R.

1149. *Specific Heat of Liquids.* **D. Negreano.** (Comptes Rendus, 128. pp. 875–876, 1899.)—The author describes a rapid method of comparing the specific heats of two liquids by heating up equal volumes in a test-tube by a coil carrying an electric current. E. E. F.

1150. *Heat of Fusion.* **G. Tammann.** (Wied. Annalen, 67. 4. pp. 871–878, 1899.)—The author investigates the dependence of the heat of fusion upon temperature and pressure, in order to decide the question as to the existence of a critical state between solid and liquid. For that to be the case, it is necessary that the specific volumes of the body in the two states become equal, and that at the same time the difference of energy of the unit mass becomes zero. The author does not acknowledge that this has yet been proved in a single instance. An apparently continuous transition from the crystallised to the liquid state is only observed when the conditions are unfavourable for seeing the dividing surface. E. E. F.

1151. *Temperature Regulator.* **E. Gumlich.** (Zeitschr. Instrumentenk, 18. pp. 317–320, 1898.)—A description of a temperature measurer based on the principle of the Metal-thermometer. Two strips of metals with expansion coefficients which differ as much as possible, *e.g.*, nickel and brass, are joined together throughout their length and bent into a spiral, one end of which is fixed and the other controls a pointer which moves over a large dial. A change in temperature of 100° in one case produced a movement of the pointer of over 360°. The details of the arrangement are best shown by the perspective sketch given in the paper. J. J. S.

1152. *Expansion of Ice.* **E. L. Nichols.** (Phys. Rev. 8. pp. 184–186, 1899.)—In view of the conflicting results obtained by Petzholdt, Brunner, Struve, Marchand, and Plücker and Geissler with regard to the thermal expansion of ice, the author has utilised a spell of exceptionally cold weather at Ithaca to make some further measurements. These were made on bars of artificial ice 45 cm. long, and the open-air temperature fluctuated between $-3°$ and $-17°$. The marks observed in the microscopes were the rims of small drops of mercury lying in hollow cavities in the ice. The coefficient obtained was 54×10^{-6}, which agrees best with Struve's value. E. E. F.

1153. *Compressibility of Gaseous Mixtures.* **D. Berthelot.** (Comptes Rendus, 128. pp. 1229–1231, 1899.)—The compressibility of a mixture of two gases may be calculated from that of its components. The compressibility of a mixture of x molecules of one gas with $1-x$ of another is represented, like that of the gases separately, by the formula of Van der Vaals. The co-volume B of the mixture equals the mean of the co-volumes b and b' of the constituents :—

$$B = bx + b'(1-x).$$

The specific molecular attraction A is obtained by admitting that, if the mutual attraction of two molecules of the first gas is proportional to a and that of two volumes of the second gas proportional to a', the attraction between two molecules of different gases is proportional to $\sqrt{aa'}$, so that

$$A = ax^2 + 2\sqrt{aa'}\,x(1-x) + a'(1-x)^2.$$

The constants a and b have the following values for the gases mentioned :—

	H	N	CO_2	SO_2
a	0·00050	0·00105	0·00913	0·02840
b	0·00114	0·00067	0·00243	0·00535

The observed increase of pressure on mixing various gases is 3·9 mm. for $SO_2 + H_2$, 1·4 mm. for $SO_2 + CO_2$, 1·0 mm. for $CO_2 + H_2$, and 0·2 mm. for $H_2 + O_2$.

The calculation of the compressibility of a gaseous mixture is quite feasible, but only within the limits of the applicability of Van der Waals' equation. E. E. F.

ELECTRICITY.

1154. *Expressions of Maxwell and Hertz for Magnetic Energy.* **H. Poincaré.** (Écl. Électr. 18. pp. 361–367, 1899.)—In this paper the author begins by setting out Hertz's expression for $\frac{d\alpha}{dt}$, where α is the x component of magnetic force, with the corresponding expression given by Maxwell for $\frac{da}{dt}$, where a is the component of magnetic induction. Hertz's formula is expressed in Maxwell's notation. He states that "magnetic induction" is not used in the same sense by the two writers. With Hertz its components are $\mu\alpha$, &c. With Maxwell they are $\alpha + 4\pi A$, &c.; and the two expressions are identical only if there be no permanent magnetisation. He then compares the expression given by the two writers for the magnetic energy. Maxwell, he says, gives two, viz., $\frac{1}{2}\int(A\alpha + \&c.)d\tau$, applicable when there is only permanent magnetisation, and $\frac{1}{8\pi}\int(a\alpha + \&c.)d\tau$, applicable when there is no permanent magnetisation. Hertz gives—

$$\frac{1}{8\pi}\int\mu(\alpha^2 + \beta^2 + \gamma^2)d\tau,$$

with a corresponding expression for the electric energy. Poincaré arrives at the result that Hertz's $\frac{d\tau}{dt}$ has the same value whether $\mu = 1$ or not; and that the components of mechanical force are $(\gamma v_o - \beta w_o + \alpha m)$, &c., whereas Maxwell gives $(cv_o - bw_o + am)$, &c. Here u_o, v_o, w_o are components of total current, and m is the density of magnetisation. He draws the following conclusions, viz.: (1) Hertz's expression for the energy is to be adopted, and not Maxwell's; (2) The like for the mechanical force; (3) The electric energy with K for μ may be treated in the same way. It is assumed that magnetised bodies are capable of displacement without deformation or change of their permanent magnetisation. In the fifth section the author deals with induced magnetisation, following Weber's method. S. H. B.

1155. *Mechanical Theory of Electricity.* **Holzmüller.** (Elekt. Runds. 16. pp. 18–20, 31–33, 46–47, 1898.)—In these articles the author summarises a few of the general results of modern views concerning the mechanical theory of electricity. R. A.

1156. *Conduction of Electricity in Gases.* **J. J. Thomson.** (Phil. Mag. 47. pp. 253-268, 1899.)—The electrical conductivity possessed by gases under certain circumstances is regarded as due to the presence in the gas of charged ions, the motion of these ions in the electric field constituting the current. In the present mathematical investigation, account is taken of the production of the ions, the recombination of the ions, and the movement of the ions under the electric forces. It is assumed that the velocity of an ion is proportional to the electric intensity acting upon it. Expressions are then obtained exhibiting the relation between the current and the electric intensity under certain conditions. Curves are also given showing the potential gradient between two charged plates between which charged ions are present.

E. H. B.

1157. *Graphic Representation of Electric Fields.* **E. Bourdréaux.** (Comptes Rendus, 128. pp. 882-883, 1899.)—Attempts to illustrate graphically the course of the lines of electric force, after the fashion of Faraday's magnetic lines, usually fail on account of the attraction, charge, and subsequent repulsion of the electrified metallic powder. The author has, however, succeeded by employing a powdered inferior conductor, sprinkled over a homogeneous and well-insulated non-conducting glass plate. Diamidophenol, crystallised in small needles, answers very well. Cork, elder pith, powdered sugar, and a great variety of other substances may also be employed. The curves are fixed with varnish in the usual way. E. E. F.

1158. *Instantaneous Polarisation.* **H. Pellat.** (Comptes Rendus, 128. pp. 1218-1220, 1899.)—The author shows that the theory of fictitious or instantaneous polarisation is powerless to explain the forces produced on a non-electrified dielectric placed in an electric field. He supposes a condenser formed of two metallic armatures half immersed in a liquid, and separated by a solid dielectric of the same specific inductive capacity K as the liquid; the solid, however, only reaching to the centre of the armatures, and projecting below into the liquid to such a distance that the field at its edge may be considered as zero. The thickness of the solid dielectric is e, and its breadth l. Air fills up the rest of the space. On establishing a difference of potential between the armatures, the solid dielectric experiences a force—

$$F = \frac{V^2 l (K-1)}{8\pi e}$$

tending to raise it, as may be proved from thermodynamical considerations, and has been experimentally shown by the author. The theory of instantaneous polarisation cannot account for this force. It is also unable to account for residual charge and other phenomena, as the author showed in his treatise on "Electrostatics not Founded on Coulomb's Law." The author's own theory of persistent polarisation is more successful.

E. E. F.

1159. *Persistent Polarisation.* **H. Pellat.** (Comptes Rendus, 128. pp. 1312–1314, 1899.)—Residual charges may be explained on a hypothesis formulated as follows: A (solid or liquid) dielectric, suddenly placed in an electric field, takes a polarisation which is not instantaneous, but which increases with the time and tends asymptotically towards a maximum. If the field ceases the polarisation decreases, and becomes zero after a time which is theoretically infinite. The truth of this hypothesis is proved by a number of experiments, one of which is the following: A block of ebonite was cut in two and rejoined. The block was then placed between the armatures of a condenser, the armatures being parallel to the cut. After a few minutes' exposure to the field, the latter was reduced to zero, and one of the pieces was inserted between the plates of a smaller condenser connected with an electrometer. The electrometer always indicated a charge, which varied with the face presented to the condenser plates, and gradually diminished. That there was no charge due to conduction was shown by an ice-pail measurement, which failed to show any charge of the piece of ebonite as a whole. E. E. F.

1160. *Volume-Changes of Gases under High E.M.F.* **H. Mache.** (Wien Akad. Sitzber. 107. pp. 708–730, 1898.)—Into the middle of a sphere made of sheet brass was brought a platinum wire pointed at the end and insulated from the sphere. The platinum point was raised to a measured potential by being connected to the pole (+ or −) of a Holtz machine, the other terminal of the machine and also the brass sphere being joined to earth. A gauge, connected to the interior of the sphere, which was in succession filled with different gases (air, hydrogen, and carbonic acid), enabled the change of volume of the gas (whether expansion or compression) to be measured. The following are the results obtained from the experiments:—

1. Gases change their volume if they are exposed to the influence of a strong electric force.

2. This change of volume cannot be explained as due to heating of the gas. It may be either a contraction or an expansion. The former is explained through polarisation, the latter through electrification.

3. If a gas is electrified, its volume increases; or if the volume is kept constant, then the pressure rises. When the electrification is interrupted this effect ceases quickly and completely in con-

sequence of the rapid diffusion of the electrified gases into the surrounding unelectrified space. Its magnitude is dependent on the indicated potential of the electricity.

4. On the discharge of an influence machine or Ruhmkorff through air, a sudden rise of pressure takes place, which instantaneously vanishes if the discharge ceases. This has its origin in the expansion of the electrified air, in connection with the electrically charged metallic vapour. J. J. S.

1161. *Equivalent Resistance and Inductance of Wire to Oscillatory Discharge.* **E. H. Barton.** (Phil. Mag. 47. pp. 433–441, 1899.)—As far back as 1886 Rayleigh deduced expressions for the equivalent resistance and inductance of a wire to alternating currents which follow the simple harmonic law and are of constant amplitude. The present paper considers the case of logarithmically damped harmonic oscillations, and the result arrived at shows that *both resistance and inductance are increased by the damping.* By applying this result to a previous experimental investigation (Abstract 284, 1899), the author finds that somewhat better agreement is obtained with theory than that given by Rayleigh's formulæ for undamped oscillations. A. H.

1162. *Kathode, Lenard, and Röntgen Rays.* **W. Sutherland.** (Phil. Mag. 47. pp. 269–284, 1899.)—J. J. Thomson's hypothesis that the mattter in the kathode stream consists of atoms resolved into particles of that primitive substance out of which atoms have been supposed to be composed, is not an absolutely necessary hypothesis. Thomson and Kaufmann have established that kathode rays travel at the same speed in H_2, air, and CO_2; and that m/e, mass of each particle by the charge it carries, is the same for all gases in kathode discharges, and in hydrogen is about 10^{-3}, the same ratio in ordinary electrolysis. The reasoning is as follows: N particles from the kathode, each of mass m and with velocity v, strike a thermopile and give up their potential energy $\frac{1}{2}Nmv^2 = W$. The total electric charge of the N particles is $Ne = Q$. Whence $\frac{1}{2}v^2.m/e = W/Q$. But on passing through a magnetic field of strength H, at right angles to the track of the particles, the force tending to deflect each particle is Hev, at right angles to H and v: and each particle describes a circular path of radius ρ with centrifugal force $mv^2/\rho = Hev$; whence $v.m/e = H\rho$. By measuring W/Q and $H\rho$, v and m/e can be found from these equations. Deflection in an electrostatic field leads to similar results. But it is assumed in all this that a charge e must be associated with some mass m. If this is not necessarily so, the charges will travel as free electrons in the ether, say as charges on modified portions of the ether: let us say as spherical shells of radius a. Certain actions of such a moving electron take place as if it had a localised inertia, so that the whole may have a kinetic energy due to motion: but the term corresponding to m is itself a function of the velocity, except where the velocities are small. In kathode discharges, from this point of view, the electrons which travel are the same in all gases: the gas is like a lubricant, but does not control the discharge; and the stream of electrons will give up its kinetic energy to the thermopile, the energy appearing as heat, for the process is irreversible. When m/e is 10^{-7} (e being measured in electromagnetic units), with Heaviside's relation, kinetic energy of electrons $= \mu e^2 u^2/3a$; also $\mu = 1$ and $e = 10^{-21}$ in electromagnetic units; the radius a is found to be 10^{-14} cm., as against 10^{-8} cm. for the radii of molecules. The electron must therefore have great freedom of movement in the interstices even of solid bodies: and there appears to be no need to take friction into account, though the velocities are, say, one-third as great as that of light.

The view that electricity exists in separate natural units, the electrons (Stoney, Helmholtz), is now generally accepted. It is not necessary to assume the electron to be always associated with an atom to form an ion. If different atoms attract electrons with different amounts of force (v. Helmholtz, Faraday Lecture, 1881), the electron must somewhat resemble the atom and have inertia, and it must also be capable of being separated from an atom. If a positive and a negative electron unite to form a "neutron" (analogous to a molecule of matter), Trowbridge's results show that the ether insulates until the electric force at some point is sufficient to decompose the neutrons into electrons, whereupon it becomes a conductor of the same type as electrolytes. The ions undoubtedly present in the kathode stream are quite subordinate to the stream of electrons; but the proportion between the ion stream and the electron stream varies according to circumstances. On impact on a thin aluminium window the ions are filtered out; the electrons get through as Lenard rays. Lenard rays and kathode rays both carry negative electricity; both originate Röntgen rays; both colour haloid salts; both have magnetic and electric deflectability; both can excite luminescence; and so forth. The colouring of salts would be by the electrons attaching themselves to electro-negative atoms, forming ions, and liberating uncharged atoms of the metal in very small quantity. Fatigue of fluorescence would be due to the electrons, already lodged, repelling those following them; and also to a change of "colour," manifesting itself not as visible colour but as a lowering of fluorescent power. If each electron be small enough merely to deform an atom upon impact and not appreciably to move it as a whole, the energy lost by electrons upon impact would appear as energy of vibration of the atoms; and if the velocity of propagation of a deformation-disturbance in all atoms is the same and the time of encounter between an electron and an atom constant, the energy given up by the electron will be proportional to the density of the substance of the atom. In a solid, as the electron threads its way between molecules, the number of impacts varies as the thickness of the solid; and for unit thickness, the coefficient of absorption will be proportional to the density of the substance of the atom, that is, very nearly, to the density of the solid: which is Lenard's law for the absorption of kathode rays. In gases there is much more free path: the number of impacts is proportional to the number, n, of molecules per unit volume and to the mean sectional area, πR^2, of each molecule; and as the coefficient of absorption also depends upon the density of the molecule, that is, varies as m/R^3, we have, taking these together, the coefficient of absorption $\propto n . R^2 . m/R^3$, or $\propto nm/R$, or ρ/R, where ρ is the density of the gas; and it therefore varies not only directly as the density of the gas, but also inversely as the molecular radius. This helps to explain the apparently abnormal absorption of hydrogen as observed by Lenard. The approximate equality of A/ρ (A being the coefficient of absorption) for different substances, solids and gases, would seem to show that it is only approximately normal impacts of an electron upon an atom that cause the former to lose kinetic energy; and if that be so, the true law for solids would be the same as that for gases. Also the approximate equality might come nearer to identity of value if we broke up the effect upon a molecule into the effects upon its component atoms. This theory explains why the Lenard rays, on emerging from the window, pass in all directions; the electrons emerge from the intermolecular interspaces in directions distributed at random. In metallic conduction there seems to be a Grothuss chain action, without any great rush of electrons at any one time and place; the nature of the metallic atom, by electromotive force (Helmholtz), favouring the local dissociations of the neutrons into electrons. That Lenard's rays can pass through gases at ordinary pressures, or at high vacua, in which the kathode rays could not have been formed, shows that the electrons are not stopped until they meet enough resistance to destroy their momentum, once they have been started. Röntgen rays may be explained, better than by the theory of their being electromagnetic pulses, by considering them as due to internal vibrations of the electrons, these vibrations being always damped by the associated atom unless the electrons are free, and therefore not accompanying ordinary light; and such vibrations would naturally originate where kathode or Lenard rays were being "absorbed" by the electrons being robbed of their translatory kinetic energy on impact. The wave-length would be small and the wave would pass freely through molecular interspaces, but would be liable to absorption near the surfaces of molecules. With such waves there would be no refraction: in reflection we would have to consider the surface of each molecule, not that of the aggregate of molecules, the result being diffuse scattering; polarisation could not be detected by our apparatus, since the rays coming through the interspaces would not be affected by the structure of the molecules of our crystals, &c. Further, such waves would not be affected by the neutrons in the intermediately vibrating ether; but when they fell upon the electrons associated with atoms in matter, the damping effect of the atoms would tell, and the atom and electron would be set into some form of mutual action and reaction, say relative motion with fluorescent and photographic effects, or with escape of the electron from the atom, or with association of the electron with an atom to form an ion, as in the ionisation of gases. Air through which Röntgen rays are passing should emit Röntgen rays in every direction, as it does, for the rays are simply reflected from the individual molecules. As to the absorption of Röntgen rays by different substances, if n be the number of atoms per unit of volume, and R the radius of each, the quantity of surface encountered per unit area of wave front $\propto n^{\frac{2}{3}}R^2$ and the number of encounters per unit distance $\propto n^{\frac{1}{3}}$, so that the energy absorbed by the atoms $\propto nR^2$. If the energy absorbed on a collision of wave with atom also varies as the density in the atom, then here again the coefficient of absorption $\propto \rho/R$, as with Lenard rays. There are special resonance phenomena of fluorescence; but with Röntgen rays the most important factor is the density, though it is not the only one. That different Röntgen ray apparatus give out various radiations which are variously absorbed is not explained by the theory of thin electromagnetic pulses: but is explained by harmonics of a fundamental vibration of the electrons. Two colliding kathode streams could not give rise to Röntgen rays, because the collisions are so few. The present theory would lead to the conclusion that it ought to be possible to get an anode stream of positive electrons (qu. Becquerel rays), and also that the velocity of the kathode stream goes on diminishing as it travels, while that of Röntgen rays should be of the order of the velocity of light, perhaps less, for to such short wave-lengths the neutrons may act as if they loaded the ether. **J. J. Thomson** (Phil. Mag. 47. pp. 415–416, 1899) comments on the preceding paper. He had considered the view that the atoms are themselves made up of electrons, but thought it wanted clearness and led to difficulties, and preferred the view that the carriers were the small corpuscles of which the atoms could be supposed to be built up. A difficulty in the way of the electron theory is the large proportion of heat developed on the impact of kathode rays: electrons striking say aluminium would produce much less. A. D.

1163. *Velocity and Magnetic Deflection of Kathode Rays.* **E. Wiechert.** (Göttingen Nachrichten, 3. pp. 260–293, 1898.) —Experiments are described in which the velocity of the charged particles constituting kathode rays is determined by observations of their behaviour in a rapidly alternating magnetic field. The kathode rays are produced at one end of a long glass tube, and travel along its axis through a slit in a fixed screen to a second slit, beyond which is a detector composed of phosphorescent glass. The second slit and the detector can be moved along the tube. Two air-condensers in series, charged by a Tesla oscillator, discharge through two equal loops of wire in parallel circuit, thus producing two alternating magnetic fields of calculable high frequency. One of these loops surrounds the glass tube longitudinally (so that the lines of force are transverse to the direction of kathode rays) between the origin of the rays and the fixed slit; the other loop is movable and surrounds the tube longitudinally between the second slit and the glass detector; we may suppose the planes of these loops to be vertical for the sake of description. When the kathode rays pass and the magnetic field is excited the rays broaden out into a fan-shape, the upper and lower boundaries being brighter than the rest and representing the deflection of the rays by the maximum magnetic field, positive and negative. By means of an auxiliary magnet the system is deflected until only the rays on one boundary of the fan pass through the fixed slit, so that rays will only start from the first slit for the second one when the magnetic fields have maximum intensity. If these rays travel with finite speed they may arrive in the movable magnetic field at a time when the field has zero intensity, thus undergoing no deflection between the second slit and the detector; or they may arrive when the field is opposite in phase to the original one and thus suffer maximum deflection in the opposite direction. Both these cases are obtained in the experiments; the velocity of the charged particles is thus deduced from the distance travelled by them in the period of alternation of the magnetic fields. The experiments give a value of one-tenth to one-fifth of the velocity of light for the speed of the kathode particles, and a probable value of $1{\cdot}0 \times 10^8$ to $1{\cdot}5 \times 10^8$ coulombs per gramme for the electric charge carried by them.

J. L. H.

1164. *Ball Coherers.* **E. Branly.** (Comptes Rendus, 128. pp. 1089–1092, 1899.)—After his experiments with metallic discs the author has tried the effect of substituting for them a row of balls 1 cm. in diameter. Since the large surface of the discs considerably reduces the density of the currents induced by the electric waves, it is to be expected that balls are much more sensitive, and this is actually the case. Brass gives no result, and lead gives only very feeble indications of sensitiveness, but ten balls of soft iron mounted one above the other show an initial resistance of 990 ohms, which is reduced to 60 by a spark of 1·5 mm. passing at a distance of 10 m. A slight shock sends it up to 1,300 ohms, and a second spark brings it down again to 80. Hard steel shows, under the same circumstances, the following succession of resistances: 600, 50, 2,060, 120, 2,520, 90. An important point is that a ball coherer, consisting of six hard steel balls, is just about as sensitive as a coherer of gold filings, which, as we know, is highly sensitive. But to obtain uniform effects the shock used for decohering must be carefully graduated. Slight repeated shocks produce conductivity. A stronger single shock produces resistance. A very hard knock brings about a nearly permanent resistance, which is not annulled by ordinary waves. E. E. F.

1165. *Electrolytic Coherers.* **T. Tommasina.** (Comptes Rendus, 128. pp. 1092–1095, 1899.)—A very sensitive coherer may be constructed by enclosing a drop of mercury in a glass tube between two cylindrical brass electrodes. This fact was discovered by the author, and led him to investigate the properties of liquids with reference to electromagnetic waves. For this purpose he immersed a copper disc and a pendulum bob in distilled water. Both conductors had previously been coated with a film of electrolytic copper and well washed. On passing a current through the two electrodes, a black deposit was formed on the disc, which grew until a chain of particles, probably cupric oxide, joined the two electrodes. On increasing the distance between them, the current was not interrupted, but the chain grew until it again united both electrodes, even when 3 cm. apart. The chain followed the pendulum bob on displacing the latter to the right or to the left. The chain is sometimes invisible. If a small incandescent lamp is inserted in the circuit, and the bob suddenly removed to 3 cm., the lamp remains alight even before a visible chain is formed. When the distance between the electrodes is very small, a chain may be formed simply by the action of electromagnetic waves, and the author has constructed a coherer on that principle, with a very thin layer of distilled water. E. E. F.

1166. *Magnetic Decoherer.* **T. Tommasina.** (Comptes Rendus, 128. pp. 1225–1226, 1899.)—Working with coherers made of magnetic metals, the author has made the important discovery that the presence of a magnet immediately destroys the conductivity of the coherer created by the impact of the electromagnetic wave. He has applied this discovery to wireless telegraphy, by substituting an electromagnet for the tapping device used by Marconi. The electromagnet is fixed a few millimetres above the tube containing the filings, which is kept in a horizontal position. The circuit is formed by an accumulator, a resistance and a relay for opening and closing the circuit of the electromagnet, with two accumulators and a telephone receiver in a suitably shunted branch circuit. The adjustments once being made, the messages work perfectly with tubes containing steel, iron, cobalt, or nickel filings. The movement of the filings is clearly visible with the naked eye, and resembles a pulsation of striking regularity. The instrument is not put out of order by the shaking of the floor nor by knocks given to the coherer. As in other cases where electric or magnetic processes are substituted for mechanical effects, much is gained in the way of precise control of the action in question. E. E. F.

1167. *Absorption of Electric Waves.* **E. Branly** and **G. Le Bon.** (Comptes Rendus, 128. pp. 879–882, 1899.)—The authors recently proved that a metallic enclosure, hermetically sealed, is an absolute protection against the influence of electromagnetic waves. They have since investigated the screening action of certain insulators or feeble conductors such as are met with in the practical work of wireless telegraphy. They operated with hollow blocks of cement, building stone, and sand. In each of the blocks a small cubical chamber was left free, to contain the coherer. It was closed by a thick iron door, through which the wires were conducted. The ringing of a bell indicated the impact of waves upon the coherer. Without a screen, the coherer responded to the exciter at a distance of 40 m. and more. It was found that the opacity of the substances tested depended much upon their nature, condition, and thickness. Sand and stone are very transparent, especially in the dry state. Portland cement is very opaque, wet sand almost equally so. To quote a few figures: Block of cement, with walls 10 cm. thick; the bell ceases to sound at a distance of 7 m. After drying, the distance becomes 12 m. The same, 30 cm. thick, is absolutely opaque while wet. Block of stone transparent. When wetted for several days the reaction ceases at 25 m. In the case of a block of stone, transparent when dry, the bell becomes silent at 25 m. if the stone is wetted for several days. E. E. F.

1168. *Propagation of Oscillations along Parallel Wires.* **W. B. Morton.** (Phil. Mag. 47. pp. 296–302, 1899.)—The author applies Heaviside's method to the treatment of electric waves along a circuit of parallel wires in the case where the wave trains are *damped* and where the circuit is *not distortionless.* The circuit is said to be distortionless when $R/L = K/S$, where R, L, K, and S are respectively the resistance, inductance, leakage conductance, and capacity, all per unit length of the line. The *velocity of propagation* of the waves along an ordinary circuit is shown to be slightly less than v, the velocity of free radiation, but reduces to v simply for the distortionless circuit. The *attenuation* of the waves in their passage along the leads is similarly shown to be slightly greater than the simple value generally used, viz., $e^{-\left(\frac{R}{2Lv}+\frac{K}{2Sv}\right)z}$, but reduces to this for the distortionless circuit. The reflection of the waves at a terminal bridge and the possibility of complete absorption are also dealt with. It is shown that the reflection factor is more complicated than for the simple theory, and that complete absorption is not possible. Numerical values are then given, applicable to the circuit used by E. H. Barton (see 1899, Abstract No. 284) in recent experiments on attenuation. These show that the velocity of propagation is $\{1 - \cdot 00000035\}$ times that of free radiation, the attenuation is 1·000091 times that on the simple theory, and that the minimum reflection factor for a terminal resistance is 0·0004 instead of zero, and is to be obtained by using a resistance equal to (1·00009) L*v* instead of L*v* simply. E. H. B.

1169. *Oscillations Round a Theoretical Hertzian Oscillator.* **K. Pearson** and **A. Lee.** (Roy. Soc. Proc. 64. pp. 246–248, 1899.)—By a theoretical Hertzian oscillator is meant a Maxwellian "double point," and the investigation for such a double point with a *steady* wave train was originally made by Hertz. The theory was insufficient for two reasons (both recognised by Hertz himself), viz. (1), the actual oscillator has sensible extension, and (2) the wave train is not steady. The present investigation only attempts to remove the latter objection to Hertz's original theory; like that theory, it becomes less accurate as we approach nearer to an actual oscillator. The writers have also attempted to replace the well-known Hertzian diagrams of the field by a more complete series, representing the field for seven complete oscillations, and showing how the field for some 12 metres round the oscillator chosen gradually falls to nearly one-fiftieth of its maximum initial strength. They next deal with the type of waves propagated, their velocities and their phases. The following general conclusions are reached:—

(i.) Three waves of electromagnetic force may be considered as sent out from the oscillator, and not merely two, as supposed by Hertz. These are: (*a*) a wave of purely transverse electric force; (*b*) a wave of electric force parallel to the axis, briefly termed the wave of lineal electric force; (*c*) a wave of magnetic force.

(ii.) The velocities of these waves undergo remarkable changes in the neighbourhood of the oscillator, but these changes extend to distances which are greater than those within which a great proportion of Hertz's interference experiments were made.

(iii.) The point of zero phase for both (*a*) and (*b*) does not coincide with the centre of the oscillator, so that these waves appear to start from spheres of small but finite radius round the oscillator. A fourth wave, dealt with by Hertz, viz., the wave of magnetic induction, does not, as he supposes, start with zero phase from the origin, but with a finite phase. The wave in the equatorial plane is a compound of (*a*) and (*b*), and has a much more complex series of velocity changes than Hertz appears to have realised.

(iv.) The existence of the two electric force waves and the singular points, or surfaces, for the wave motion in the neighbourhood of the oscillator very possibly throw light on the difficulties which arise in Hertz's experiments. It would seem that such experiments should be made at distances greater than 6 to 7 $(\lambda/2\pi)$ from the centre of the oscillator, or, roughly, about a wave-length from the oscillator. In Hertz's case they amount to about 10 metres—a distance at which Hertz rather terminated than started his interference experiments. Only at such a distance are the phase curves sensibly linear. D. E. J.

1170. *Copper Temperature-Coefficient.* (Elect. Rev. 44. p. 531, 1899.)—The usual correction 0·228 per cent. per degree F. is not justified by Clarke, Forde, and Taylor's experiments. They obtain an arbitrary parabolic formula which closely follows their experimental facts, viz.:—

$$\frac{R}{R_{32}} = 1 + \cdot 0023708\ (t-32) + \cdot 00000034548\ (t-32)^2.$$

A set of tables based on this result has been produced by these experimenters. M. O'G.

1171. *Electric Conductivity of Nitric Acid.* **V. H. Veley** and **J. J. Manley**. (Phil. Trans. 191. pp. 365–398, 1898.)—The acid was purified with scrupulous precautions, described in full; and the percentages of acid ranged from 1·30 to 99·97. At 0° C., the specific resistance, in true ohms, fell at first more, then less rapidly, from 19·924 at 1·30 per cent. to 1·722 at 30·42 per cent.; then rose slowly to 4·758 at 76·59 per cent., and then more rapidly to 73·663 at 96·12 per cent.; and again fell to 54·733 at 98·50, 26·554 at 99·27, and 25·688 at 99·97 per cent. The temperature-coefficients in the formula $R_t = R_0\ (1 \pm \alpha t \pm \beta t^2)$ for different concentrations are tabulated at page 391. Nitric acid between 96·12 and 99·97 per cent. behaves as a metallic conductor in possessing a negative temperature coefficient of conductivity. Sulphuric acid has an analogous maximum of density at 98·78 per cent. The authors find the curve representing the conductivity units in terms of percentages to be markedly discontinuous at $HNO_3 . 2H_2O$, at $HNO_3 . H_2O$, and at $2HNO_3 . H_2O$; and the temperature coefficients go through minima and maxima at these three hydrates and also at $HNO_3 . 3H_2O$. A. D.

1172. *Capacity of Telephone-Cables.* **F. Breisig.** (Elektrotechn. Ztschr. 20. pp. 127–131, 1899.)—The mutual relation of the conductors in a sheathed twin-cable can be approximately represented by three condensers connected in series, with the terminal plates of the first and last condensers connected to earth. The capacities of the two intermediate connecting wires, *i.e.*, of the wire between the first and second, and of the wire between the second and third condenser of the series, are analogous respectively to the capacities of the two conductors in the twin-cable, and expressions can at once be written down for the capacity of each conductor with respect to the earth, and for the capacity of each with respect to the other. This analogy can be extended to the case of a telephone cable containing more than two conductors. A further approximation can be made by assuming that the multifold conductors are arranged symmetrically within a metal cylinder. The author considers one particular pair of conductors of this symmetrical system, and on the theory of electric images traces the corresponding equipotential surfaces. An expression is deduced for the capacity of the pair of conductors in terms of the diameter of the wire, the distance between the two conductors, and the radius of the containing cylinder. R. A.

1173. *Detecting Faults on Picking up Submarine Cables.* **E. Jona.** (Electrician, 43. pp. 15–16, 1899.)—Currents are induced in the turns of cable which pass on to the picking-up drum. The galvanometer is connected between the picked-up end of the cable and the earth. The galvanometer throw shows a sudden alteration as soon as the fault passes over the drum. Details of a satisfactory trial at sea in 1898 are given. M. O'G.

1174. *Detecting Faults on Picking up Submarine Cables.* **W. J. Murphy.** (Electrician, 43. pp. 12–13, 1899.)—The variations of a high resistance fault which is being raised from the bottom increase the difficulties. An induction method similar to E. Jona's (see preceding Abstract) was tried in 1891. The use of high frequency, the earthing of the far end, the use of a telephone, a secohmeter, a Wehnelt interrupter and a condenser on the ship are suggested. M. O'G.

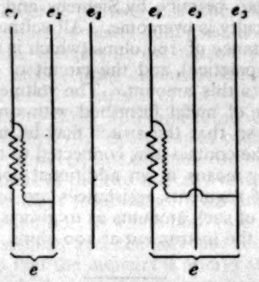
1175. *Earth-currents in Germany.* (Archiv. Post. Tele. 4. pp. 110–112, 1899.)—Since 1881, observations have been made and recorded at the telegraph stations of the principal towns in Germany in order to determine the strength, direction, and duration of earth-currents over a large continental area. The currents follow a very regular sequence, with a primary epoch of twenty-four hours. They are greatest at midday, and least at midnight; the current-curve between those two points takes a wave form of approximately thirty-six periods a day, with a submaximum at 4 a.m. The direction is at midday south-east, afterwards veering round to south, west, north, and east. At 4 a.m. the direction is opposite to that at noon. At night the reversals are less regular than during the day. In addition to the diurnal variations, the currents undergo a sudden diminution between November and December of each year, and an equally sudden rise in January and February; they are strongest in spring and autumn, weakest in winter, and almost as strong in summer as in autumn. The reversals are less regular in winter than at other times of the year. The similarity of year to year observations is very remarkable. R. A.

1176. *Comparing Low Resistances.* **J. B. Pomey.** (Écl. Électr. 18. pp. 247–249, 1899.)—This paper investigates the best conditions for comparing two low resistances by shunting each of the coils of a differential galvanometer with one of them.
E. C. R.

1177. *Strain and Thermoelectric Properties.* **M. Maclean.** (Roy. Soc. Proc. 64. pp. 322–330, 1899.)—Kelvin describes in vol. ii. of his Mathematical and Physical Papers a number of qualitative experiments to determine the direction of thermoelectric currents in the same metal when one part of it is left unstrained and the other is strained in various ways. The object of the experiments described in the present paper was to determine the *magnitude* of the thermoelectric effects in similar cases. Junctions were formed between pieces of drawn and undrawn wire made from specimens of copper in different states of purity, and also from lead, reostene, platinoid, German silver, and manganin. The currents produced between the drawn and undrawn portions (one junction being heated in a glycerine bath and the other kept at the temperature of the room) were measured by means of a low resistance galvanometer, and the values in micro-amperes are given by the author. From these were deduced the thermoelectric differences in microvolts per degree difference of temperature. The analyses of the specimens of copper wire and the densities and specific resistances of the drawn and undrawn wires of the various materials are also given in the paper. J. J. S.

1178. *Luminous Electrolytes.* **E. Lagrange.** (Comptes Rendus, 128. pp. 1224–1225, 1899.)—The author has been studying the luminosity of the layer of dielectric surrounding an electrode since 1891. He discovered and described the "unstable" phase which is now known to be accompanied by rapid intermittence. After the publication of Wehnelt's contrivance, he set himself to produce the unstable phase at the kathode instead of the platinum anode. The interest attached to this attempt lies in the fact that at the anode only a noble metal can be used, in consequence of the evolution of nascent oxygen, whereas the hydrogen developed at the kathode would not even perceptibly attack iron. The main difficulty lies in the rapid rise of temperature of the liquid, which soon brings about the stable condition with continuous current. The author, therefore, constructs the kathode of small bars of copper attached to a large sheet of the same metal outside the liquid. The sheet presents a large cooling surface, which keeps down the temperature. The sheet may also be replaced by a copper vessel containing cold water constantly renewed. The author has thus succeeded in interrupting currents of 40 to 100 amperes, with or without inductance in the circuit, and in imitating Wehnelt's induction-coil phenomena. E. E. F.

1179. *Measurement of Phase-Difference in Induction Motors.* **C. Breitfeld.** (Elektrotechn. Ztschr. 20. p. 120, 1899.)—Let a three-phase induction motor with star coupling of circuits be connected to three-phase mains, and let e_1, e_2, e_3 stand for the P.D.s across the circuits. The phase-difference φ between the



P.D. and current in any circuit may be determined from the two deflections x_2 and x_3 of a wattmeter connected in the two ways shown in the accompanying diagram. If k stand for the wattmeter constant, then, in the first position shown, the power is—

$$kx_2 = ei \cos(\phi - 30°),$$

and in the second it is—

$$kx_3 = ei \cos(\phi + 30°),$$

from which $\tan\phi = \sqrt{3}\,\frac{x_2 - x_3}{x_2 + x_3}$. The author has not tested the method experimentally. A. H.

1180. *Measurement of P.D. at Feeding-Points.* **J. Teichmüller.** (Elektrotechn. Ztschr. 20. pp. 246–247, 1899.)—In German Central stations the mean value of the P.D. at the various feeding-points of a network is commonly ascertained by bunching together all the positive and all the negative pilot-wires and connecting them to a single voltmeter. The same voltmeter is frequently also used for ascertaining the P.D. at single feeding-points or groups of feeding-points—a measurement which will indicate in how far the network performs its function of equalising the potential. From considerations of economy the pilot-wires are small (1 mm. dia.), and are embedded in the insulation of the feeders. All the pilot-wires are adjusted to the same resistance by means of equalising resistances connected in series with them. It is usual to graduate the station voltmeter with a resistance in its circuit equal to that of a pilot-wire, so that when connected to a pair of pilot-wires it will correctly give the P.D. at the feeding-point. It is obvious that if the same instrument is used for measuring the mean P.D. of all the feeding-points, or any group of them, its readings will be too high, on account of the reduced drop due to parallel connection of the wires. The author shows that with ordinary electromagnetic instruments and lengths of pilot-wire such as occur in practice, the error may be considerable, amounting to as much as 5 per cent. in some cases. He then describes an arrangement recently patented by himself, and introduced into practice by Siemens and Halske, by means of which the difficulty is overcome. All voltmeters are calibrated with a series resistance of 100 ohms (which is never exceeded by any pilot-wire in practice), and the circuit of each pair of pilot-wires is made up to this amount. The voltmeter switch consists of a circular plate of metal furnished with a number of contacts of varying width, so that the switch may be made to cover one, two, or more of the contact-pins connected to the pilot-wires. At the same time, by means of an additional contact which glides over a number of segments, resistances are introduced into the voltmeter circuit, of such amounts as to always maintain the total resistance outside the instrument at 100 ohms. A. H.

1181. *Wehnelt's Interrupter.* **E. Thomson.** (Elect. Engin. N.Y. 27. pp. 239–240, 1899.)—The author gives a general account of the Wehnelt current-interrupter, and then describes the ordinary effects. The response of the apparatus to the closing of the circuit is extremely quick. In taking radiographs of the thorax, the closing of the circuit can be so timed with the breathing that the ribs are always in the same position when exposed to the rays. (Elect. World and Elect. Engin. N.Y. 33. pp. 334–335, 1899.)—This interrupter furnishes a means for performing experiments hitherto regarded as requiring alternating currents. The repulsion of rings, rotation of discs, and similar phenomena can be demonstrated, using a coil of comparatively few turns wound upon an iron wire core. Cores for the coils used with the interrupter should generally be of the open magnetic circuit type. The author has, however, devised for this purpose a closed-circuit core; it has an auxiliary reverse winding which, when the interrupter is "open," magnetises the iron oppositely to the primary turns. The effect is similar to that of an alternating current. R. A.

1182. *Interrupters for Induction Coils.* **F. Dessauer.** (Elektrotechn. Ztschr. 20. pp. 220–223, 1899.)—The author reviews critically the various forms of interrupter which have been devised from time to time. The ordinary vibrating contact-breaker is very serviceable for coils of moderate size. It is simple, clean, and cheap, but not very suitable for coils of large size, as there is then the danger of the platinum contacts becoming fused together and thus producing a short circuit; further, this form of contact-breaker is incapable of giving high-frequency interruptions. For securing the latter, motor-driven mercury interrupters are used. The two great drawbacks to mercury interrupters are: (1) The excessive amount of oxidation, which soon interferes with regular working, and necessitates frequent cleaning of the mercury; (2) The fact that the surface of the mercury is thrown into waves, so that if the contact-pin happens to descend into the trough of a wave it may miss contact. In order to get over this latter difficulty, Kohl and Ernecke make the mercury vessel hour-glass shaped, the contact-pin dipping into the mercury at the narrow part of the vessel; but the difficulties arising from oxidation are thereby increased, on account of the smaller surface of mercury. A considerable improvement is due to Bose, who introduced two mercury interrupters, driven by cranks 180° apart, one at each end of the motor spindle; there is, however, considerable difficulty in accurately adjusting the positions of the two mercury vessels so as to get the same duration of contact from each. This difficulty is absent in the form due to the author, in which both interrupters are at the same end of the spindle, and the mercury vessels communicate with each other, so that the mercury is always at the same level in both. For very high frequencies, the mercury interrupter due to Boas deserves notice: a vertical tube of glass, the lower end of which dips into a mercury vessel, and the upper end of which is bent at right angles to the length of the tube, is rotated at a high speed; the horizontal rotating jet of mercury is directed against a toothed or perforated metal ring. In conclusion, the author describes his modification of the ordinary platinum contact-breaker; this is noticed in the following abstract. A. H.

1183. *Interrupter for Induction Coils.* **F. Dessauer.** (Zeitschr. Elektrochem. 5. pp. 357–359, 1899.)—The modification intro-

duced by the author consists in using two contacts (one on each side of the spring) instead of one, so that as the spring vibrates it closes and opens the circuit twice during each complete oscillation. At first sight the arrangement appears impracticable, for one might expect the armature to remain in contact with the core once it is attracted towards it and the circuit closed. But the resilience of the vibrating-spring is sufficient to tear the armature away from the magnetised core and break the circuit. The advantages claimed for this arrangement are:—longer contact, and hence longer sparks for the same make-and-break frequency, and double the frequency for the same period of vibration of the spring.
A. H.

1184. *Wehnelt's Interrupter.* **A. Blondel.** (Comptes Rendus, 128. pp. 876–877, 1899.)—The author reproduces some oscillograph curves showing that at 40 periods per second the current is first established as in all inductive circuits. The electrolysis increases until a gaseous envelope is produced round the anode. Then there is a sudden interruption of the current, and, at the same time, an enormous increase in voltage. Then both the current and the pressure reassume their initial values, and the action begins again.

Under these conditions the phenomenon of interruption only occasions one single aperiodic impulse. The energy $\frac{1}{2}LI^2$ accumulated in the self-induction, and liberated by the interruption of the current, causes the condenser formed by the polarised anode in the electrolyte to be charged at high potential. This condenser destroys itself by discharging in an arc which is formed between the platinum and the electrolyte, and drives away the dissociated oxygen. The anode is therefore immediately freed from gas, and is again in contact with the liquid which condenses the vapour, if any remains, and permits the current to flow again immediately. This action may be approximately compared with that of a hydraulic ram or a pulsometer. This explanation allows one to understand the necessity of a certain proportion between the self-induction and the anode without it being necessary to liken the phenomenon to a true resonance. One understands also why the employment of a high voltage, which increases the rapidity of the electrolysis, can increase the frequency. Finally, the form of the pressure curve suffices to explain the large increase of the mean pressure at the terminals of the cell, pointed out by Wehnelt and Pellat. The oscillograph used did not lend itself to an examination of the action at high frequencies, but one may fairly believe that the phenomenon preserves the same character whatever the frequency.
E. E. F.

1185. *Diffraction Galvanometers.* **P. Weiss.** (Comptes Rendus, 128. pp. 876–877, 1899.)—The sensitiveness of a galvanometer can, according to the author, be almost indefinitely increased by constructing it on a smaller and smaller scale, or by employing a greater and greater optical enlargement for reading the angles. But a limit is set by the resolving power of the mirror. A mirror of 1 cm. diameter should, according to Foucault's rule, separate two readings 12 sec. apart. Practically about 5 sec. can be observed, and this, on account of the doubling, means an actual deviation of 2·5 sec. But the same author has devised a means of considerably increasing the sensitiveness by diffraction. He uses a mirror, 1 × 0·4 cm. in area, suspended with its greater length in a horizontal position. The centre of the mirror is blackened, while the ends, 4 mm. × 3 mm., are left bare. The radius of curvature of the mirror is 4 m. It is illuminated by an incandescent filament placed at the centre of curvature. The rays reflected by the mirror produce, at the same distance, the usual phenomenon of diffraction at infinity for the case of two openings. The enlarged image of the filament is seen in the focal plane, traversed by two black fringes, which are sharply defined. On taking the position of one of them as a datum, a micrometric eye-piece will easily discover a displacement of 0·025 mm. This is less than a second of arc, and at least four times as sensitive as the usual method. E. E. F.

1186. *Ampere Balance.* **W. E. Ayrton** and **J. V. Jones.** (Elect. Engin. 22. pp. 653–654, 1898. Paper read before the British Association at Bristol.)—The proposed new instrument is distinguished by the fact that the counterpoise weight is determined purely by calculation based on the dimensions of the instrument, the number of turns in the coils, and the value of *g* where the balance is set up. The authors remark that "the proposed ampere balance and the existing ampere standard will differ exactly in the same way as do a Lorenz apparatus and the Board of Trade ohm standard, verified 1894." G. B. M.

1187. *High Resistance Standards.* **F. B. Fawcett.** (Phil. Mag. 46. pp. 500–503, 1898.)—Gold-platinum films are deposited in vacuo on a glass plate by means of a grid-shaped kathode. The film is then boiled for several hours under reduced pressure in an oil-bath; in this it is then hermetically sealed. Seven months' observation on three such films show percentage variations of resistance as follows:—

A. +0·0130 to −·0082. B. +0·0055 to −0·0086
C. +0·0005 to −0·0004,

the mean resistances being 97110, 161360, and 502500 ohms respectively. G. B. M.

1188. *Mercury Voltameter.* **L. Gourwitch.** (Electricien, 17. pp. 66–67, 1899.)—This is a description of a mercury voltameter which can be used for the measurement of electric currents of any magnitude. W. G. R.

1189. *Therapeutic Electrostatic Apparatus.* **W. J. Morton.** (Elect. Engin. N.Y. 27. pp. 245–246, 1899. Read before the Société Française d'Electrothérapie, January, 1899.) — Priority concerning the applications and terminology of interrupted currents from induction machines for the purpose of producing continuous muscular contraction. Morton also suggests putting the patient on an insulating stool and connecting the electrodes to one of the conductors of the machine, which conductors are placed so as to maintain a spark-gap. H. B.

1190. *Photographing Variable Current Curves.* **H. J. Hotchkiss.** (Phys. Rev. 8. pp. 152–160, 1899.) — This apparatus, which is portable, consists of two Deprez-type galvanometers, mounted one above the other, each with a soft iron moving part 1 mm. wide, 1·9 mm. long, and 0·06 mm. thick, mounted with a mirror one-third as large as itself on a quartz fibre, the latter being supported at both ends by a quartz bow or rod about 1 mm. diameter and 1 cm. long. The iron is between the poles of a strong permanent or electro magnet, and is deflected by the current passing through coils whose field is at right angles to the controlling field of the permanent magnet. Needles have been made having a natural frequency of over 8,500, and with a strong field and stiff fibre a frequency of 10,000 can be obtained. Sunlight or arc-light is directed through two narrow slits in the side of the containing box upon the two mirrors. From the mirrors the two beams are reflected upon a horizontal slit in the box containing the revolving drum. As the needles are deflected by the current, the spots of light move along the slit and trace the curves in the film, which moves rapidly at right angles to the slit. The drum box may be removed and replaced by a slide-way for using plates.

The paper gives illustrations of the apparatus and photographs of various curves of alternating currents obtained with it.

No method of artificial damping is used in this apparatus. E. C. R.

1191. *New Transformer Diagram.* **F. G. Baum.** (Phys. Rev. 8. pp. 95–111, 1899.)—An analytical investigation of the problem of the transformer, accompanied by a number of vector diagrams illustrating the results of the analysis. The author obtains expressions for the primary and secondary currents for any given resistance and reactance in the secondary, and arrives at the following results: Any transformer may (so far as the *primary* current taken by it is concerned) be replaced by a single coil having a coefficient of self-induction equal to $R_1 (L_1/R_1 + L_2/R_2)$, a resistance equal to that of the primary, and an E.M.F. whose value is $\sqrt{B^2+C^2}$ times the primary P.D.; this apparent E.M.F. being in advance of the real primary P.D. by an angle $\tan^{-1}\frac{B}{C}$. In the above, R_1 and R_2 stand for the resistances of the primary coil and secondary *circuit*, and L_1 and L_2 for the self-inductances of the primary and secondary *coils* respectively; B and C being defined by the equations—

$$B = \sin\phi + \tan\theta_2 \cos^2\theta$$
$$C = \cos\phi + \tan\theta_2 \sin\theta\cos\theta,$$

in which ϕ is the angle between **H** and **B**; $\theta_2 = \tan^{-1}\frac{Lp}{R_2}$; and θ is the angle of lag or advance (due to inductance or capacity, or both) of the secondary current from its normal phase at right angles to the magnetic flux. In the same manner, so far as the *secondary* current is concerned, the transformer may be replaced by a single coil having a resistance equal to that of the secondary *circuit*, a self-inductance equal to $R_2 (L_1/R_1 + L_2/R_2)$, the E.M.F. acting on the coil being taken as $\frac{EMp}{R_1}\cos\theta$, where E is primary P.D., and M mutual inductance of two coils $(M = \frac{N_2}{N_1}L_1)$. The main advantage claimed by the author for his method is that it enables us to deal with either circuit independently of the other.

A. H.

1192. *Magnetic Induction in Iron Rods.* **J. L. W. Gill.** (Phil. Mag. 46. pp. 478–494, 1898.) The rod examined, which is straight, is fixed co-axially inside a standard solenoid, and a small search-coil, in circuit with a d'Arsonval ballistic galvanometer, is adjustable, by a sliding arrangement, at any desired position on the rod. The solenoid and a secondary coil serve to calibrate the galvanometer. By observing the induced current when the field is reversed, the induction across a section of the rod is calculated. For specimens of round or square section and length less than thirty times the diameter of the section, the observations show that if B_0 is the maximum induction, B that at a distance x from the centre, then the following relation is very nearly true:—

$$(B/B_0)^{\frac{5}{2}} + (x/a)^2 = 1,$$

a being a constant depending on the dimensions of the specimen.

When the rod is put through a cycle, let L_1 be the average loss of energy per unit volume due to hysteresis; then there is a relation—

$$L_1 = KB_1^{1\cdot 6}$$

where—

$$B_1 = \sqrt[1\cdot 6]{B^{1\cdot 6}\text{ mean.}}$$

The author calculates B_1 from this formula: the results show that for specimens of different relative dimensions the ratio B_1/B_0 does not vary much, and is constant when the length is less than thirty times the diameter: its value is then ·768.

G. B. M.

1193. *Magnetism in Ferro-Nickels.* **L. Houllevigue.** (Journ. de Physique, 8. pp. 89–94, 1899.)—The author suggests a possible physical explanation of the existence at the same temperature of magnetic and non-magnetic forms of the same ferro-nickel alloys, the former being say 2 per cent. greater in volume than the latter (Hopkinson). These alloys are much more heterogeneous than their moderate thermal conductivity would have led us to expect. In nickel, traction diminishes while pressure increases the magnetic susceptibility; in iron below the critical strength of field the action is the converse of this. If each iron nucleus be compressed sufficiently by its nickel shell (*i.e.*, iron and nickel or some nearly equivalent alloys of the two) the iron would, in moderate fields, have no magnetic susceptibility at, say a pressure of 400 kgrms. per sq. mm. The equilibrium of pressure reached in the pasty state would be disturbed so as to produce such a pressure on cooling. Then break the shell mechanically and the pressure is relieved and the system reassumes, with increase of volume, its magnetic susceptibility. Cold may do the same thing, and the more readily so the thicker the nickel shells. The modulus of elasticity also alters by 10 per cent. on transition to the magnetic condition; and the relation of the one to the other is discussed. A. D.

1194. *Diurnal Variations of Magnetic Disturbances in Polar Regions.* **G. Lüdeling.** (Berlin Akad. Sitzber. 14. pp. 236–246, 1899.)—Lüdeling had established (Abstract No. 71, 1899) that, in polar regions, the vector diagrams of the magnetic elements show a counter-clockwise movement, if all days are considered, and a clockwise movement—as generally in medium latitudes—if quiet days are alone taken into consideration. In this paper he deals with the diurnal disturbances, proceeding after the manner of P. A. Müller's inquiry into the magnetic elements of Pawlowsk, 1884. The calculations and the vector diagrams based upon them concern eleven stations, situated in high latitudes, from Pawlowsk, lat. 59° 41′, up to Cape Thorsden, lat. 78° 28′, and, as before, the summer months of 1883. The radius vector of the disturbance diagrams describes a counter-clockwise movement, whilst the normal daily variations follow the hands of the clock. The diagrams are, however, fairly symmetrical with regard to the magnetic meridian and appear stretched out in that direction, and the disturbing forces seem to be inversely proportional to the horizontal force. Kingua Fjord again makes the exception. This station is near the magnetic and auroral north poles, and shows a very small X-component (south-north) and abnormal earth-current phenomena. The unknown disturbing forces of polar stations have obviously a period of twenty-four hours. H. B.

1195. *Bar Magnets.* **V. Guillet.** (Ecl. Electr. 18. pp. 441–446, 1899.)—The apparatus used by the author consists of a hollow cylinder of copper, to the upper portion of which is fixed a simple vertical rectangular copper frame, the whole being suspended by a fine wire provided with a torsion head. The current is led into the cylinder by a number of very fine loose silver wires, flows up the cylinder, at the top bifurcates, one half of it passing up each half of the rectangular frame, which it leaves at the top by another series of fine silver wires. Two adjustable frames are provided for holding the bar magnet which is being tested; by means of the first frame, the magnet may be held with its axis vertical and coincident with that of the hollow cylinder, by which one end of it is completely enclosed, so that the whole of the magnetic lines thread themselves through the cylinder; by means of the second frame, the magnet may be held in a horizontal position, with its axis at right angles to, and passing through the centre of, the rectangular frame above the cylinder. The torque acting on the cylinder in the first position of the magnet is a measure of the intensity of magnetisation; while the second position affords a means of determining the position of the "pole" of the magnet, the position of the magnet being adjusted until it exerts maximum torque on the rectangle. By means of this apparatus, the author studies the effects of temper and various methods of magnetisation, and of ratio of length to diameter, on the magnetisation and position of the poles of the magnet. He finds that the distance between the poles increases with increasing intensity of magnetisation. A. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1196. *Crystalline Structure of Metals.* **J. A. Ewing** and **W. Rosenhain.** (Roy. Soc. Proc. 65. pp. 85–90, 1899.)—Etched polished surfaces of iron, mild steel, nickel, and various other metals, showing the crystalline structure of the material, develop, if the etched piece be subjected to stress, a number of parallel bands within the crystalline areas. The direction of these bands, which under the microscope appear like crevasses, varies in different crystals and bears no relation to the direction in which the load is applied, although at first the average general tendency is for them to be markedly at right angles to the direction of pull or pressure. As the material becomes more and more permanently deformed, one or often two other sets of lines occur, crossing those first formed. Polished but unetched surfaces show all these lines equally well. Oblique illumination proves the lines to be due to superficial differences in level, and points to their being caused by slip occurring within the crystals along planes of cleavage, or gliding planes. The crossing lines are similarly due to slips subsequently developed along different lines of cleavage. Silver, gold, copper, lead, bismuth, tin, gun-metal and brass, but not hard steel, can be readily made to show these lines under magnifications of from 140 to 1,000 diameters.

It would thus appear that the plasticity of metals is due to numerous internal slips occurring at intervals along cleavage surfaces within the crystals, whereby the crystal-grains are deformed. Slipping in three directions enables the grain to accommodate itself to its envelope of neighbouring grains. The flow produced by these intra-crystalline slips involves an expenditure of work in an irreversible manner. The metal is therefore plastic, because it is made up of irregular crystals within which these slips may occur—each crystalline grain changing its shape through slips occurring within itself, and its position through slips occurring in other grains. W. G. M.

1197. *Velocity of Crystallisation.* **A. Bogojawlensky.** (Zeitschr. Phys. Chem. 27. pp. 585–600, 1898.)—Various substances were examined by melting them in clean glass **U** tubes of 2 mm. internal diameter, with limbs 15 and 18 cm. long respectively, and partly immersing these tubes in a bath of water or glycerine heated to the melting-point of the substance examined. The usual precautions were taken to prevent premature solidification on the walls of the tubes. The linear measurements were taken by means of glass scales clipped to the limbs of the **U** tubes.

Crystallisation was started by a nucleus of the solid substance introduced on the end of platinum wire at the desired temperature of examination, which ranged commonly from 10° to 60° below the fusing temperature. Thus Tammann's earlier observations were, with certain substances, confirmed, but not so with others. With benzyl, sulphonal, picric acid, mannite, erythrite, santonin, and other substances the velocity of crystallisation, expressed in mm. per minute, increased with the number of degrees below the fusing-point at which the crystallisation was started, up to a certain limit beyond which it was constant, no matter to what extent the material was cooled, within the limits of practicability. This number depended upon the substance and upon its purity. For mannite and santonin it was reached at 25°, for benzyl, sulphonal and picric acid at 35°, and for erythrite and antipyrin at 60° below the normal. The velocity ranged from 36 mm. per min. in the case of santonin to 880 mm. in the case of picric acid. The limit of constant velocity has not yet been reached in the case of dinitrophenol and coumarin, although the former has been crystallised from sur-fusion at a temperature 75° below the normal. W. G. M.

1198. *Velocity of Hydrolysis of Maltose.* **A. von Sigmond.** (Zeitschr. Phys. Chem. 27. pp. 385–400, 1898.)—The following are a few of the results of the author's work: The hydrolysis of Maltose follows Wilhelmy's Law, and is therefore a reaction of the first order. The constant expressing the rate of hydrolysis is a function of the temperature, and this function can be expressed by Arrhenius' exponential equation for the inversion of cane sugar. Hence the reactivity of maltose is increased as the temperature rises, and, as in the case of raw sugar, there may be considered to exist, under given conditions, a constant ratio between active and inactive maltose molecules. In the exponential equation, $A_m = 17127{\cdot}29$, for maltose hydrolysis, determined at temperatures between 63·7° and 83·76°. The corresponding constant for cane sugar at temperatures below 69·24° is $A_n = 12820$. Hence the hydrolysis of maltose is affected more strongly by temperature than is the inversion of cane sugar. The concentration of maltose solution increases its reactivity. The rate of reaction varies with the conditions, but at 69·24°, and in the presence of normal acetic acid, the rate of reaction of cane sugar undergoing inversion is 1132·63 times greater than that of maltose during hydrolysis. Finally, not only the reactivity of the acids, but the nature and quantity of the sugar used, are found to exert a considerable influence on the hydrolysis of the various sugars. W. G. M.

1199. *Reaction Velocity.* **A. A. Noyes** and **G. J. Cottle.** (Zeitschr. Phys. Chem. 27. pp. 580–584, 1898.)—The reaction examined is that expressed by the following equation:—

$$2Ag\,C_2H_3O_2+HCO_2\,Na=2Ag+CO_2+HC_2H_3O_2+NaC_2H_3O_2$$

or, in accordance with the dissociation theory—

$$2Ag+HCO_2'=2Ag+CO_2+H'$$

The experiment was conducted at 100° C. by breaking a small tube containing a solution of sodium formate within a larger tube carrying a solution of silver acetate, and after a thorough stirring, watching the progress of the reaction by titrating a portion of the liquid with potassium permanganate. It was thus found that the rapidity of the reaction was proportional to the concentration of the sodium formate solution and to the square of the concentration of that of the silver acetate, which is in agreement with theory. W. G. M.

1200. *Reaction Velocity.* **A. v. Hemptinnes** and **A. Bekaert.** (Zeitschr. Phys. Chem. 28. pp. 225–240, 1899.)—The work of Menschutkin (Z. P. Ch. 5. p. 589. & 6. p. 41) on the combination of $N(C_2H_5)_3$ and C_2H_5Br is extended to a large number of pure and mixed solvents. The chief results are:—

1. The constant for C_2H_5Br bears a nearly constant ratio to that for C_2H_5I in benzene, chlorbenzene, xylene and acetone; in the alcohols it is somewhat lower.
2. Increase of temperature increases the constant in the same ratio in benzene and in acetone.
3. Many binary mixtures give a constant differing little (5 to 15 per cent.) from that calculated by the rule of mixtures: others, like the alcohols mixed with benzene, xylene, acetone, &c., are 30 to 80 per cent. higher than the calculated values.
4. Ternary mixtures give constants which differ more, but can be approximately calculated by regarding them as mixtures of one constituent (benzene, xylene, &c.), with a binary mixture (determined as above). B. B. T.

1201. *Velocity of Inversion.* **E. Cohen.** (Zeitschr. Phys. Chem. 28. pp. 145–153, 1899.)—The inversion velocities of 10 per cent. cane sugar by N/2 to N/128 HCl in water and 20 per cent. and 50 per cent. alcohol are determined: some of the constants found are as follows:—

Conc. HCl	N/2	N/8	N/32	N/128
Water	775×10^{-6}	157×10^{-6}	365×10^{-7}	852×10^{-8}
20% Alcohol ..	...	152 ,,	347 ,,	830 ,,
50% Alcohol ...	640 ,,	114 ,,	248 ,,	573 ,,

The ratio—velocity in alcohol to velocity in water—increases with diminishing concentration of acid, and is constant at 1·04 for 20 per cent. and 1·49 for 50 per cent. alcohol: the ratio is the same for 5 per cent. The velocity in each solvent is proportional to the concentration of H ions (as calculated from the conductivity): the author therefore retracts his former statement. (See following Abstract; also 1898, Abstract No. 538.) B. B.T.

1202. *Theory of Reaction Velocity.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 28. pp. 317–335, 1899.)—The author refers to his former hypothesis (Zeitschr. Phys. Chem. 4. pp. 231–234, 1889) of active and inactive molecules to explain reaction-velocity. The proportion of active molecules increases rapidly with the temperature; in the case of Zn and H ions the maximum is reached, whence the slight temperature-coefficient of the solution-velocity of zinc in acids (Ericson, Bihang d. Stockholm Accod. 22. 2. p. 21, 1897). The influence of pressure (Rothmund Zeitschr. Phys. Chem. 20. p. 175) and the velocity of crystallisation (contrary to Tammann's calculation) (Wied. Ann. 62. p. 292, 1897) agree with this theory.

The increase of velocity in catalytic processes with increase of concentration, is shown to be the same as the increase of osmotic pressure; cane sugar obeying in both cases the formula $G/p = A\,(1 + 0{\cdot}013p)$ where G is the velocity (or osmotic pressure), p the percentage of sugar, and A a constant.

The osmotic partial pressure must therefore be substituted for the concentration in the application of the law of mass action: the theoretical proof by means of semi-permeable membranes is given by van't Hoff (Zt. P. Ch. 1. p. 500). The increase in velocity on adding foreign substances (salts, &c.) is similarly explained. This increase is in first approximation proportional to the amount of foreign substances whatever the concentration of the reacting substances; the change of ionisation in the latter is, of course, corrected for. The effect of increased viscosity on adding foreign substances is shown by theoretical (kinetic) considerations to be slight.

The author controverts Cohen's statement that the degree of ionisation cannot be calculated from the conductivity (see 1898, Abstract No. 538, and Zeitschr. Phys. Chem. 25. pp. 1–45), pointing out that the diminution of reaction-velocity in alcoholic solutions (Kabulokow and Zacconi), just as the increase with rise of temperature, &c., must depend on some such specific action of the solvent as the author's theory predicts. Van Laar's argument for Cohen's statement based upon the solubility determinations of Goldschmidt and Marseveen (see 1899, Abstract No. 1056) is erroneous. When the variability of the ionisation with the concentration is taken into account, the observed values agree well with those calculated from the ionisation as usually determined (from conductivity). (See also preceding Abstract.)

B. B. T.

1203. *Alloys of Iron and Nickel.* **F. Osmond.** (Comptes Rendus, 128. pp. 304–307, 1899.)—The points of transformation of alloys of nickel and iron are determined by observing the temperatures at which the magnetic properties disappear on heating (A) and reappear on cooling (B). For alloys containing more than about 26 per cent. of nickel these temperatures are probably the same, the apparent difference being due to experimental error. The following table contains some of the observed values :—

Percentage composition.				
Carbon.	Manganese.	Nickel.	A.	B.
0·19	0·79	0·27	735°	715°
0·17	0·68	7·65	710	530
0·16	0·32	24·75	540	27
0·61	0·46	26·20	0	<0
0·23	0·49	31·44	138	124
0·30	0·68	43·04	401	357
0·08	0·41	69·20	590	557
0·12	0·38	88·95	488	457
0·12	0·55	98·50	384	345

T. E.

1204. *Occlusion of Hydrogen and Oxygen by Palladium.* **L. Mond, W. Ramsay,** and **J. Shields.** (Phil. Trans. 191. pp. 105–126, 1898.)—Palladium black, obtained by precipitation, contains 138 volumes of oxygen (1·65 per cent.) and 0·72 per cent. of water. When heated in oxygen it absorbs the gas continuously up to a red heat, forming a dark brown substance which is, without doubt, an oxide or mixture of oxides, since it does not lose oxygen at a red heat in a vacuum. That the phenomenon is one of oxidation is also shown by the fact that the heat of absorption per gram atom of oxygen (+ 187K) is intermediate between the heats of formation of palladious and palladic hydroxides. Palladium black absorbs over 1,000 volumes of hydrogen, but part of this forms water with the oxygen originally present. The amount actually occluded was found to be 854–868 volumes, the greater part of which is removable by pumping at the ordinary temperature, and practically the whole at 444°. Palladium sponge absorbs 833 volumes of hydrogen, 99 per cent. of which can be pumped off at the ordinary temperature. Increasing the pressure up to 4·6 atmospheres does not influence the absorption. Palladium foil does not absorb hydrogen until it is converted into a spongy mass by repeated ignition ; the gas is easily expelled at 100° C. in a vacuum. The heat of absorption per gram of hydrogen is 46·4 K ; or, deducting the heat corresponding to the work done by the atmosphere, 43·7K. This value differs greatly from that found for the heat of absorption by platinum black (66·1K), from which it is inferred that occlusion does not consist simply in the liquefaction or condensation of the gas in the pores of the metals. The atomic ratio of palladium to hydrogen in the fully charged metal ranges from 1·37 to 1·47, corresponding nearly with the formula Pd_3H_2; this appears, however, to be almost the only evidence there is for the existence of such a compound. N. L.

1205. *Solid Solutions.* **H. P. Cady.** (Journ. Phys. Chem. 3. pp. 127–136, 1899.)—Naphthalene and monochloracetic acid form two series of solid solutions, naphthalene being the main constituent of the one series and monochloracetic acid of the other. Liquid mixtures of the two substances are allowed to solidify partially at a suitable temperature, which is maintained constant for some hours until equilibrium between the solid and liquid phases is established. These are then separated and analysed. The following table contains the results (the meaning of which is, however, best seen from the curve representing them). The naphthalene melted at 79·9°, the acid at 62°; the numbers indicate molecules per 100 molecules of the mixture :—

NAPTHALENE SERIES.

	SOLID SOLUTION.		LIQUID SOLUTION.	
Temp.	Naphthalene.	Acid.	Naphthalene.	Acid.
75°	96·6	3·4	84·4	15·6
70°	95·4	4·6	67·7	32·3
65°	89·2	10·8	53·3	46·7
60°	80·3	19·7	42·4	57·6
55°	59·6	40·4	31·3	68·7
53·5°	—	—	29·4	70·0

ACID SERIES.

60°	1·7	98·3	4·0	96·0
55°	2·1	97·9	21·0	79·0

At the quadruple point (53°) a liquid solution, and two solid solutions of the following compositions are in equilibrium :—

Solid solutions { 43 napthalene, 57 acid.
2·5 ,, 97·5 ,,

Liquid solution { 28·7 naphthalene.
71·3 acid.

Glycollic acid behaves in a similar way; acetic acid, and probably malonic and succinic acids, however, do not form solid solutions with naphthalene. T. E.

1206. *Explosive Properties of Acetylene.* **G. Claude.** (Comptes Rendus, 128. pp. 303–304, 1899.)—Under atmospheric pressure, at − 80°, acetone dissolves more than 2,000 times its volume of acetylene. A platinum wire, heated to bright redness by an electric current, does not cause this solution to explode. Liquid acetylene itself at about − 80° and under a pressure of 1·3 atmospheres (its own vapour pressure) behaves in the same way.

T. E.

1207. *New Atmospheric Gases.* **W. Ramsay.** Mem. Manchester Lit. and Phil. Soc. 43. 4. pp. 1–19, 1899.)—A lucid account of the chief results of the author's researches and their bearing on the kinetic theory and on the periodic law. (See 1898, Abstract Nos. 1370 and 1371, and 1899, No. 841.) T. E.

1208. *Molecular Weight of Sulphur.* **H. T. Barnes.** (Journ. Phys. Chem. 3. pp. 156–159, 1899.)—The author endeavours to ascertain the molecular weight of sulphur in carbon disulphide solutions by means of empirical relations deduced from Pfeiffer's measurements of the densities of such solutions. F. G. D.

1209. *Determining Molecular and Atomic Weights.* **D. Berthelot.** (Journ. de Physique, 8. pp. 263–274, 1899.)—The author describes the method as being based on the law of Gay-Lussac and the Avogadro-Ampère principles. But the latter principle could be exact for different temperatures and different pressures only if all gases had the same compressibility and the same coefficient of expansion. But Regnault's experiments show that the coefficients of expansion of different gases (under constant pressure and constant volume) approximate more and more closely to a common value (about 1/273) as the pressure diminishes. Thus Gay-Lussac's laws are limiting laws, exact for very low pressures: under these conditions of extreme rarefaction the molecular volumes of all gases may be taken as exactly equal. The limiting density of a gas (under an infinitely small pressure) cannot be measured experimentally; but it can be deduced from its normal density (at 0° and atmospheric pressure) if the law of compressibility of the gas be known. The molecular weights of gases are then proportional to their limiting densities. The methods of calculation are described, use being made of the results and investigations of Regnault, Van der Waals, Amagat, Rayleigh, Leduc, and Sacerdote. The physical method gives the following atomic weights (oxygen = 16): hydrogen, 1·0075; carbon, 12·004; nitrogen, 14·005; sulphur, 32·050; argon, 39·882. The values for hydrogen and carbon agree excellently with those obtained by the chemical method. In the case of nitrogen the latter method is indirect. Stas found N = 14·044; but other cycles of reactions give lower numbers, *e.g.*, 14·019 (Thomsen) and 14·012 (Hill). Stas's value for sulphur is S = 32·058. It is interesting to note the magnitude of the error that would arise in this case through taking the normal instead of the limiting density: the former would give S = 33·55. The value for chlorine given by the physical method (35·479) differs sensibly from that found by Stas (35·456). The former is based on the density of a single compound (HCl) prepared by a single method, and must therefore be regarded with reserve. D. E. J.

1210. *Solubility and Melting-point of Racemic Compounds and Inactive Mixtures.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 28. pp. 494-517, 1899.)—Racemic compounds of two optically isomeric substances may be distinguished from simple mixtures or from crystals containing the two in isomorphous mixture (pseudo-racemic mixed crystals) by means of the solubility or the melting-point. In order to do this, however, it is necessary to study the whole curve of solubility or melting-point for mixtures containing the two isomers in all proportions. The typical curves for each case are given in the paper, and without them an abstract is of little use. The following results may, however, be mentioned. The determination of the composition of the three solutions saturated (*a*) with the inactive compound, (*b*) with the inactive and the dextro-, (*c*) with the inactive and the lævo-rotatory substances is sufficient in many cases to decide the nature of the inactive substance. If it is an ordinary mixture of the dextro- and lævo-rotatory compounds, all three solutions are identical and inactive; if it is a racemic compound the first solution is inactive, the second dextro-, and the third lævo-rotatory. The curve of the melting-points of mixtures of the two isomers consists of two parts melting at an angle when no racemic compound is formed; it consists of three branches melting at angles when a racemic compound exists, and, in all probability, forms only one continuous line when the two isomers form solid solutions. The melting-point of the racemic compound may be higher or lower than that of the active isomers, and the same is true of the pseudo-racemic mixed crystals; the melting-point of the ordinary inactive mixture of the two isomers is, however, always lower than that of the isomers alone.

At temperatures below the melting-point further transformations of the solid substances may take place. These also are considered. T. E.

1211. *Volumes of Aqueous Solutions.* **E. B. H. Wade.** (Journ. Chem. Soc. 75. pp. 254–277, 1899.)—The author describes an apparatus which enables a direct measurement to be made of the change in volume which occurs when a certain volume of solution is diluted with an equal volume of water. It consists of a U tube, one arm of which originally contains a solution, whilst the other contains pure water. The U tube is terminated by fine tubes which enable changes of volume to be readily measured. In most cases the results can be represented by the empirical formula, $x = n^b/a$, where x is the contraction on 100,000 cc. of solution and water combined, n the number of gramme equivalents of dissolved substance in 100,000 cc. of mixture, and a, b, are constants. Some of the results obtained are given below, the temperature being 18°–20° C.

	KCl	NaCl	$SrCl_2$	$CaCl_2$	Cane Sugar	LiCl	HCl
a	19·1	25·0	12·59	13·275	57·15	19·28	29.45
b	1·64	1·70	1·54	1·52	2·00	1·528	1·49

The results can also, in general, be expressed by the empirical equation

$$\phi = \text{constant} + \frac{n^{b-1}}{a(2^{b-1} - 1)}$$

where ϕ is the apparent volume of one gramme equivalent of the dissolved substance after 50 per cent. dilution. A. Gs.

1212. *Photoelectric Currents.* **G. C. Schmidt.** (Wied. Annalen, 67. 3. pp. 563–577, 1899.)—The substance used by the author for producing photoelectric currents is not one of the highly sensitive silver halogens, but cupric oxide, which under the influence of light is transformed into the well-known and well-defined cuprous oxide. He immersed two plates of electrolytic copper in a normal $CuSO_4$ solution. A deflection of 13 mm. was obtained on immersion, and this increased by 5 mm. in one minute on illuminating one of the electrodes. Similar results were obtained in the case of zinc and lead, but it was always noticed that the purer the metal the less was the photoelectric effect. The author concludes that light is incapable of producing an E.M.F. at the surface of absolutely pure metals. Whatever effects are observed are probably due to a diminution of the polarisation, or to a special influence upon the gases occluded in the metal. Under the influence of light, CuO and Cu_2O undergo a slow transformation, which reduces their potential. At low potentials, cupric oxide becomes positive under the influence of light. This means that the solution pressure of the oxygen is raised. At high potentials CuO becomes positive in red light and negative in violet light. In the first case, the light raises the solution pressure of the oxygen, while in the second case it transforms the salt into the low-potential modification. E. E. F.

1213. *Electrochemical Theory, III.* **R. Mewes.** (Elektrochem. Ztschr. 5. pp. 217–223, 1899. See 1898, Abstract No. 673.)—The author continues his speculations, and claims to establish a relationship, which holds good for the gaseous, liquid, and solid states, between the refractive power of a compound and that of its constituent elements. N. L.

1214. *Neutralisation.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 199–201, 1899.)—The author discusses the thermal aspect of a number of chemical reactions, and endeavours to show that the heat of neutralisation is due, not, as supposed by Ostwald, to the combination of the hydrogen of the acid with the hydroxyl of the base, but to a loose union of acid and base. Various arguments are also brought forward in support of the theory of hydrolytic, as opposed to ionic, dissociation. N. L.

1215. *Determinations of Constitution by the Electrometer.* **R. Kieseritzky.** (Zeitschr. Phys. Chem. 28. pp. 385–423, 1899.)—The author measures the potential difference between mercury and various solutions containing organic mercury salts. The measurements are carried out in the usual way, with a subsidiary calomel electrode and a Lippmann electrometer. The potential difference thus determined serves as an index to the degree of electrolytic dissociation of the salt. The author shows that if the hydrogen replaced by the mercury is *amidic*, the dissociation is less than if it is *carboxylic*. If the replaced hydrogen is *imidic*, then the dissociation is still smaller.

The author concludes (1) that hydrocyanic acid is an *imide* compound; (2) that mercury, silver, and alkali succinimides contain the metal directly combined with nitrogen; (3) that nitrous acid is an *imide* compound, its salts and esters having the formula $R-NO_2$.

These conclusions are founded on the feeble dissociation of the corresponding mercury compounds in aqueous solution.

The paper contains further a presentation of the author's views on the subjects of isomerism of nitrogen compounds and tautomerism. F. G. D.

1216. *Freezing-points of Ternary Mixtures.* **J. Waddell.** (Journ. Phys. Chem. 3. pp. 160–164, 1899.)—"If the components of a binary solution be A and B, of which A is the one separating as solid phase, the addition of a third substance, C, slightly miscible with A and readily miscible with B, might be expected to lower the freezing-point till a certain quantity of it was added, and then to cause a rise in the temperature of freezing."

With the object of verifying this, the author has carried out a series of freezing-point determinations where A = water, B = acetone, and C = salicylic acid, phenol, paranitrophenol, hydroquinone or ether. All the substances mentioned under C, except ether, caused either no change or a rise in the freezing-point. With ether a depression was obtained, but the phenomenon was complicated in this case by the appearance of two liquid phases. F. G. D.

1217. *Demonstration of the Phase Rule.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 69–71, 1899.)—From the well-known equation:—

$$\eta\, dt - v\, dp + m_1\, d\mu_1 + \ldots + m_n\, d\mu_n = 0,$$

Gibbs concludes that there exists an integral relation between $p, t, \mu_1 \ldots \mu_n$. The author states that this conclusion is unwarranted but *correct*, and proceeds to supply the missing links.
F. G. D.

1218. *Demonstration of the Phase Rule.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 137–143, 1899.)—The author gives a proof of this theorem which, he states, is both short and complete. The various demonstrations in existence are described as being either long or incomplete. The author's discussion is certainly lucid and in some respects novel, but it is not short enough for reproduction in an abstract. (See also preceding Abstract.)
F. G. D.

1219. *Equilibrium of Stereoisomers, III.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 144–155, 1899.) — The author discusses by means of his triangular diagram the various possible equilibria which may occur in the case of two mutually convertible (*i.e.*, *tautomeric*) isomers in presence of a third substance which may form solid compounds with the former. The discussion is based on the Phase Rule and Duhem's theory of the "*curve of natural state.*" No experimental results are given, but some illustrative examples are quoted from the oximes. It is shown how the relative stability of the isomers and their compounds may be predicted from the diagram, and how the relative stability may become reversed in the latter case. F. G. D.

1220. *Mutual Solubility: Vapour Pressure and Critical Points of Mixtures.* **J. P. Kuenen** and **W. G. Robson.** (Zeitschr. Phys. Chem. 28. pp. 342–365, 1899.)—The equilibrium of two substances in the liquid state and that of vapour, which as liquids are not miscible in all proportions at all temperatures, is investigated, especially in regard to the equilibrium-pressure.

If p_1, p_2, p denote the vapour pressures of two such liquids when separate and mixed ($p_1 > p_2$), the old law gave $p > p_1$ or p_2. Konowalow, however, showed theoretically that the case $p_1 > p > p_2$ is possible, and Bakhuis-Roozeboom discovered a pair, sulphur dioxide and water, which conforms to this law.

In most cases, rise of temperature causes increase of the mutual solubility until the two liquid phases become identical, after which there is perfect miscibility in all proportions. In other cases a similar action is produced by fall of temperature, and in a third series of cases both these actions are traceable. Rothmund therefore suggested that the diagrammatic solubility-curve for every pair of liquids is closed, and has two points upon it corresponding to two critical points of perfect miscibility.

The authors point out that another case may occur wherein the vapour and the lighter liquid phase become identical before the two liquid phases do so; beyond this point, therefore, two phases alone coexist, and their composition and density must depend on the pressure as well as on the temperature, and consequently on the ratio of the amounts of the two liquids which are initially put together, so that a solubility-curve proper exists only below the critical point for the vapour and the lighter mixture and above that for the two liquid phases; and in this case it is not closed. Mixtures wherein these two critical points have been observed are those of ethane with ethyl-, propyl-, isopropyl- and butyl-alcohols: for ether and water, and also for ethane and methylalcohol, only the vapour-lighter mixture critical point has been realised.

The paper gives these interesting observations in detail.

R. E. B.

1221. *Solidification of Liquid Mixtures of Tautomeric Substances.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 28. pp. 289–301, 1899.)—The author begins by emphasising the now well-known fact that the number of components in a system depends practically on the *speed* with which possible reactions in the system take place. Defining *tautomeric* substances in the modern way as isomers—structural, geometrical, or optical—between which a more or less slow reversible transformation occurs, the author proceeds to discuss how *temperature*, as influencing the speed of transformation, may modify the conditions of the system. At higher temperatures we have comparatively rapid mutual transformation in liquids, and so are dealing with *one-component* systems. Employing a temperature-concentration diagram, we get for such temperatures a single "equilibrium-curve." If we assume that for temperatures in the neighbourhood of or below the freezing-points of the pure isomers, the speed of transformation has become practically zero, then at such temperatures the system contains two components, and we have the ordinary diagram, *i.e.*, either the two intersecting *freezing-point* curves for the two isomers, or these separated by an intermediate curve, according as a solid compound does not, or does, exist under the given conditions. Between these regions of comparatively high and comparatively low temperature, where we have either mutual transformation (resulting in a state of equilibrium which is a single-valued function of the temperature) or complete indifference respectively, Roozeboom assumes, following the example of Duhem, the existence of a region of "*false equilibrium*." In this region the single equilibrium-curve bifurcates, and the state of equilibrium ceases to be a single-valued function of the temperature. The equilibrium reached depends on which isomer one started out with.

By means of the diagram so obtained the peculiar phenomena observed in the solidification of a melted tautomer become at once evident. The various possibilities are discussed in detail by Roozeboom, and it is shown in what way the freezing-point of the melt is dependent on the temperature to which it has been raised, the length of time it has been heated, and the manner of its cooling. F. G. D.

1222. *Dissociation Studies, I.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 72–94, 1899.)—In this paper the author studies two-component systems in which a compound exists which undergoes slow dissociation in the liquid and vapour phases. In the first place a concentration-temperature diagram is employed, and it is shown how the compound may exhibit melting-points varying between certain definite limits, according to the rapidity of heating and the speed of dissociation in the liquid. Orthophthalic acid is quoted as an example, and the varying results obtained by different investigators explained by the above theory. It is shown that its stable melting-point (*i.e.*, the melting-point corresponding to complete equilibrium in the melt) is 184° C., and that phthalic acid and its anhydride apparently form solid solutions.

The author then goes on to consider pressure-temperature diagrams in which the partial-pressure curves are shown, and a discussion of this form of diagram leads easily to a demonstration of the existence under certain conditions of Van der Waal's "*maximum temperature of sublimation*" for a subliming compound which dissociates into two *volatile* components. This temperature is the highest temperature at which the solid compound will sublime *en masse*, *i.e.*, volatilise without giving rise to a liquid or a new solid phase. By interpolation the author calculates the maximum sublimation temperature for iodine monochloride and finds it to be 24° ± 1°.

By considering the influence of time when the rate of dissociation in the vapour is slow, the author shows that for a given temperature the pressure corresponding to comparatively rapid volatilisation should be lower than the equilibrium-pressure, and he further shows that a raising of the melting-point by volatilisation under diminished pressure can be similarly explained. In this way the remarkable results obtained by Ramsay and Young with aldehyde-ammonia and chloral hydrate find their explanation. In conclusion the author discusses the phenomenon observed by Ramsay and Young in the case of phthalic acid, and more especially succinic acid, viz., that the static sublimation-pressure is higher the greater the amount of acid taken. It is shown that this curious result may be explained by assuming that the anhydrides form isomorphous mixtures with the acids. F. G. D.

1223. *Osmotic Work and Pressure.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 28. pp. 220–224, 1899.)—In a previous paper the author obtained a relation between the osmotic pressure and the osmotic work, and hence deduced a value for the volume factor of the latter which is given by the equation $dv = v_0/(1 + \mathrm{P}k/2)$, where P is the osmotic pressure, k the coefficient of compressibility of the solvent, and dv the alteration in volume produced when a volume, v_0, of the solvent is added to the solution, the concentration being assumed to be constant. This volume alteration cannot be obtained experimentally, since if water is added to even an infinite volume of solution the volume change may be finite, and the concentration altered, although the alteration in pressure is infinitely small. Dieterici's calculations of osmotic pressure from the alterations of density with concentration are rendered invalid through neglect of this consideration, and it is shown that the volume alterations deduced by Dieterici are not in agreement with the values calculated from the formula given by the author. N. L.

1224. *Osmotic Pressure.* **F. Barmwater.** (Zeitschr. Phys. Chem. 28. pp. 115–144, 1899.)—The author criticises the application of the kinetic theory of gases to solutions, and frames a rival theory, in which the molecules of the solute have no freedom beyond that characteristic of ordinary liquid molecules. He proposes to verify it by measurements of the changes of volume and temperature attending dilution. E. E. F.

1225. *Osmotic Wind.* **K. Schreber.** (Zeitschr. Phys. Chem. 28. pp. 79–95, 1899.)—When air is in bodily motion, the mean squares of the molecules in three co-ordinate directions have different values. By suitably choosing the co-ordinates, two components can be made equal, while the excess of the third represents the velocity of the wind. Since the kinetic theory of gases has been applied to the theory of solutions, it is interesting to look for an analogy with atmospheric wind. Such an analogy holds good in the case of electrolytes under the influence of a current. If an aqueous solution of $Cu(NO_3)_2$ is divided into two portions by a diaphragm of copper ferro-cyanide, the latter is exposed on both sides to the impact of Cu molecules, to which it is impermeable. On passing a current through the solution the impacts are increased on one side and diminished on the other, thereby producing a difference of osmotic pressure analogous to wind. The author places this in evidence by experiments with Pfeffer cells, compensating the osmotic wind by hydrostatic pressure. He points out a fundamental difference between the phenomenon described and that of electric osmose. For a minute aperture in the thin membrane used cannot be regarded as a tube, and the membrane itself is a perfect metallic conductor. There is a proportionality between potential difference and osmotic wind pressure which does not at all agree with the kinetic theory as applied to solutions. E. E. F.

1226. *Drop Electrodes.* **W. Palmaer.** (Zeitschr. Phys. Chem. 28. pp. 257–279, 1899.)—The changes of concentration attending the contact between a metal and an electrolyte are placed in evidence by purely chemical means, without closing an external circuit. The author employs a new kind of mercury dropper, consisting of a vessel opening downwards and closed by a glass stopper having about 100 channels etched into its circumference, giving rise to as many trains of droplets. The mercury is passed out under a pressure of 5 atmospheres. The drops fall through a solution of 0·0005 – normal mercurous nitrate, in which they produce considerable differences of concentration. These are made evident by SH_2 water and indigo. This is the first purely chemical proof furnished of the transfer of ions under such conditions. The experiments confirm Nernst's theory of electrolytic solution-pressure, of which they are a simple and direct consequence. At the same time, the results bring no evidence tending to discredit Warburg's theory of electrocapillary phenomena. E. E. F.

1227. *Concentration Cells with Insoluble Electrodes.* **K. Schaum.** (Zeitschr. Elektrochem. 5. pp. 316–319, 1899.) — The cells considered have platinum electrodes immersed in solutions containing a mixture of an oxidising agent and the product formed by its reduction, for example, a ferric and a ferrous salt or a ferri- and a ferro-cyanide. Calling C_1 and C_2 the concentrations of the ferri- and ferro-cyanide ions in the one solution, C_1' and C_2' their concentrations in the other, and n the difference in the number of charges carried by the two kinds of ions, the

E.M.F. of the cell is, according to Nernst's osmotic theory, given by the equation—

$$E = \frac{RT}{n\epsilon} \log \frac{C_1 C_2'}{C_2 C_1'}$$

Experiments made with solutions of ferri- and ferro-cyanides are in good agreement with this formula. T. E.

1228. *E.M.F. of Concentration Cells.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 95–106, 1899.)—The author shows that the E.M.F. of a concentration cell is proportional to the absolute temperature only when the heat of dilution from one concentration to the other is negligibly small, and that if this latter condition be not fulfilled, the deviation from proportionality is determined by the *form* of the heat of dilution regarded as a function of the temperature and the concentrations of the two solutions of the cell.

If E=E.M.F. of cell, h_1, h_2=concentrations, Δ=heat of dilution between h_1 and h_2, Θ=thermodynamic temperature, then

$$E = \Theta . K(h_1, h_2) + \Theta . F(\Theta, h_1, h_2),$$

where

$$\frac{\partial F}{\partial \Theta} = -\frac{\Delta}{\Theta^2}.$$

F. G. D.

1229. *Ionisation of Polyvalent Salts.* **P. Calame.** (Zeitschr. Phys. Chem. 27. pp. 401–420, 1898.)—The freezing-point method was for the most part used in this research. It was thus found that copper malate in aqueous solution formed complex molecules, in which probably copper was substituted for the H of the hydroxyl group. The copper salts of citric and glyceric acids, but not those of salicylic and lactic acids (which also contain hydroxyl groups), form similar complex molecules. Magnesium fumarate is more strongly dissociated than the maleate, a fact which may find its explanation in the ionisation of the salts in different successive stages. W. G. M.

1230. *Law of Dilution of Electrolytes.* **T. P. Muller.** (Comptes Rendus, 128. pp. 505–507, 1899.—According to Ostwald, the molecular conductivity of a solution containing a gramme-molecule of a normal salt in v litres is given by the equation $\mu = \mu_\infty - \delta$, where δ is a function of v alone, provided the temperature is constant. A similar dilution law has recently been applied by Kohlrausch to the mobility of the ions themselves (see 1899, Abstract No. 331). On examining the results obtained by Kohlrausch and also by Bredig, it is seen that in a series of experiments in which the dilution is successively doubled the values of δ form a geometrical progression with a common ratio of $\frac{4}{3}$. Hence it is shown that the molecular conductivity of a solution of a normal salt containing monovalent radicles is given at 18° by the equation $\mu=\mu_\infty-52{\cdot}72v^{-0{\cdot}41504}$ and at 25° by $\mu=\mu_\infty-62{\cdot}152v^{-0{\cdot}41504}$. N. L.

1231. *Influence of a Binary Electrolyte on the Solubility of a Ternary Electrolyte with Different Ions.* **A. A. Noyes** and **E. S. Chapin.** (Zeitschr. Phys. Chem. 28. pp. 518–522, 1899.)—Calcium hydroxide is more soluble in solutions of ammonium chloride than in pure water, owing to the formation of calcium chloride and ammonia. The solubility in a case of this kind is readily calculated when the ionisation of the different salts in the solution is known. The degree of dissociation of the calcium hydroxide in saturated aqueous solution, at 25°, is found to be 0·808. The results obtained at 25° are the following, the unit of concentration used being 0·001 gram molecule per litre:—

Concentration of the Ammonium Chloride.	Solubility of the Calcium Hydroxide.	
	Found.	Calculated.
0	20·22	...
21·76	29·08	28·9
43·52	39·23	38·6
87·03	59·68	58·3

T. E.

1232. *Conductivity of Mixed Electrolytes.* **F. Barmwater.** (Zeitschr. Phys. Chem. 28. pp. 424–430, 1899.)—The author extends to the case of a mixture of electrolytes a theory developed by him (Zeit. Phys. Chem. 28. p. 131 *et seq.*) for one electrolyte. He measures the conductivities of various mixtures, namely, NaCl and KCl; NaCl and KI; NaCl and KNO_3; KCl and KNO_3; NaCl, KCl, and KNO_3; NaCl, KCl, KNO_3 and KI, and finds a good agreement between the results so obtained and those calculated from his formulæ. F. G. D.

1233. *Electrolytic Conductivity.* **R. Abegg.** (Zeitschr. Elektrochem. 5. pp. 353–355, 1899.)—The connection is pointed out between the general conditions affecting electrolytic conductivity and the fact that pure, simple liquids are practically non-conductors. In order that a liquid may be a conductor it is necessary that a substance should be present which, from its chemical constitution, is capable of furnishing ions, and that the production of the latter should be favoured by the presence of a medium having a high dielectric constant. It is also important that the electrolyte should exist in the form of directly dissociable, simple molecules, and not of complex, polymerised molecules which must undergo preliminary decomposition before ions can be formed. In the case of most liquids, however, high specific inductive capacity is associated with a high degree of polymerisation, the only exceptions being nitrobenzene, ethylic nitrate, and benzonitrile; and these liquids, from their chemical nature, are unsuited for the formation of ions. The only class of pure substances which are good electrolytes is that including fused salts, where all three conditions appear to be favourable. Little is known of the molecular state of these substances, but judging from analogy their dielectric coefficients are probably high, and they are eminently suited for the formation of ions. It is calculated that in fused silver chloride the concentration of the free ions is about 10^{-1} normal, whereas with water it is only about 10^{-7} normal. Another factor, besides those already mentioned, in the production of electrolytic dissociation is the power of the ions to associate themselves with molecules of the solvent, as is shown by the high conductivity exhibited by solutions of salts in liquid ammonia. N. L.

1234. *Influence of Membranes on Ionic Migration.* **W. Bein.** (Zeitschr. Phys. Chem. 28. pp. 439–452, 1899.)—Determinations of the relative velocity of the ions of a salt give different results according as they are made with or without membranes. The results also depend on the kind of membrane used. A comparison of results obtained without any membrane with those obtained with membranes shows that the effect of the latter is to diminish the relative velocity of the kathion. Diaphragms of parchment paper or of porous earthenware have the smallest, those of goldbeater's skin or animal membranes the largest effect. The author concludes that the phenomena may be ascribed either to the membrane possessing the character of an acid and combining with some of the kathions, or to polarisation of the membrane, which would result in the (possibly temporary) deposition of the kathions upon it. T. E.

1235. *Limiting Values of E.M.F. for Electrolysis.* **E. Bose.** (Zeitschr. Elektrochem. 5. pp. 154–177, 1898.)—The apparatus used and the manner of making the observations are fully described. It is found that the estimation of the decomposition values can be best determined with the aid of a continually increasing potential, and with the smallest possible current intensity. The divergence of the curves from the theoretical form is explained by alterations in concentration. The separation of solid deposits affords very sharp indications of the decomposition points, whilst the separation of soluble bodies, especially of gases, gives indeterminate points. Copper salts show two characteristic kathode decomposition points, of which the first is probably to be assigned to the ions $\overset{+}{\text{Cu}}\text{-}\overset{+}{\text{Cu}}$. An O_2-electrode is strongly depolarised in solutions of mercurous salts. Silver separates from nitric acid solution as $\overset{+}{\text{Ag}}$ ion. Acids usually show as many characteristic decomposition points as there are ions produced by gradual dissociation. W. G. M.

1236. *Electrolytic Reduction of Meta-nitro-toluene.* **A. Rohde.** (Zeitschr. Elektrochem. 5. pp. 322–324, 1899.)—Meta-nitrotoluene is readily reduced by electrolysis in the way described by Elbs and Kopp (Zeitschr. Elektrochem. 5. p. 108, 1899). The first product is *m*-azotoluene, which on further reduction yields *m*-hydrazotoluene, the current efficiencies being 91 and 70 per cent. respectively. T. E.

1237. *Electrolytic Estimation of Lead.* **A. Hollard.** (Électricien, 17. pp. 84–86, 1899.)—The author considers the literature of this subject is lacking in details. As under correct conditions the determination of lead as peroxide by electrolysis is simple and reliable, he publishes the methods of procedure used by himself—for various metals and alloys containing lead. The quantity of lead to be separated should not exceed ·2 gram. A platinum cone should be used as anode, and a platinum spiral as kathode. The cone should be roughened before use by immersion in aqua regia. The correct dimensions of cone and spiral are given. A glass beaker is used to contain the electrolyte, and the solution of the metal or alloy is effected in this same beaker. The deposit of lead peroxide on the anode, after washing by immersion, must be maintained for at least fifteen minutes at a temperature of 200° C. before weighing, in order to obtain the definite compound PbO_2. Detailed instructions for the application of the method to the determination of lead in the following metals and alloys are then given: 1. Pure lead. 2. Commercial zinc. 3. Commercial tin and lead-tin alloys. 4. Commercial antimony and lead-antimony alloys. 5. Commercial copper and bronzes.

It is found that the proportion of free nitric acid required in the electrolyte depends upon the presence or absence of copper. The author explains this by the theory that when copper is present the copper nitrate supplies a portion of the oxygen necessary to form PbO_2 on the anode, while when copper is absent the whole of this oxygen has to be provided by the nitric acid. In the latter case, therefore, a larger amount of free nitric acid has to be added at the commencement of the deposition.

J. B. C. K.

1238. *Electrolytic Sodium Pertungstate.* **G. E. Thomas.** (Indus. and Iron. 26. pp. 327–328, and 369–370, 1899.)—In the course of the investigation on the atomic mass of tungsten the author has studied the behaviour of sodium tungstate when submitted to electrolysis, and found that a gas was evolved which liberated iodine from potassium iodide solution. The apparatus employed consisted of a bulb with two openings, the lower aperture being covered with a parchment diaphragm. The bulb was placed in a beaker, the latter having a kathode of platinum or other metal, the platinum anode being placed inside the bulb. The solution employed consisted of 15 gr. sodium tungstate in 50 cc. of water and ½ cc. acetic acid. The current was 1·4 amperes at 107 volts. Conversion of the salt into the para condition takes place, and the solution acquires a yellow colour round the kathode. When no precipitate is produced on the addition of nitric acid after six hours the operation is stopped. On evaporation of the yellow solution below 100° C., a crop of yellowish white crystals was obtained, which, however, only consisted of a partially peroxidised salt. Various attempts to purify the salt thus obtained failed to give satisfactory results, nor did alteration in the electrolytic conditions produce a purer product. Pertungstate of soda on heating liberates ozone.

O. J. S.

1239. *Electrolytic Chlorates, Bromates, Iodates, and Hypochlorites.* **W. Waubel.** (Ind. Électrochem. 3. pp. 14–15, 1899.) —The author has found that by use of a diaphragm and of an anode solution of sodium bicarbonate, the whole of the chlorine carried into the anode chamber can be converted into chlorate. The electrolyte should be kept at 60°–70° C., the current density should be 5 to 10 amperes per sq. decimetre, and the E.M.F. should be 4 to 5 volts. The solutions of bicarbonate for the anode chamber and of chloride for the kathode chamber should be saturated. In order to maintain the former in this state, additions of fresh amounts of bicarbonate are necessary from time to time. In the anode chamber 6½ grammes of chlorate are obtained for every 7½ grammes of bicarbonate used, while in the kathode chamber a 10 per cent. solution of sodium hydrate can be obtained.

Comparing the electrical energy necessary to produce chlorate by this process with that required in the experiments of Oettel and of Gall and Montlaur, the following comparative figures are obtained :—

Oettel..............	Alkaline electrolyte without diaphragm....................	736	Watt hrs. yield	88·14 grms
Gall & Montlaur	Alkaline electrolyte with a diaphragm....................	1003	,,	,,
Waubel............	Bicarbonate in anode chamber with a diaphragm......	951	,,	,,

The latter process has the advantage over the other two, that sodium hydrate is concurrently produced, and can be recovered from the kathode solution.

Bromates and iodates can be obtained by a similar method of procedure. By operating at a low temperature hypochlorites can be produced. Potassium ferro-cyanide and chromous hydrate can be raised to the higher stage of oxidation by placing them in the anode compartment of a similar cell. The attempts to produce fluorates by this method have not yet resulted in success.

J. B. C. K.

1240. *Electrolytic Extraction of Mercury.* (Ind. Électrochim. 3. pp. 6–7, 1899.)—Cinnabar, the naturally occurring sulphide of mercury, is crushed to a fine state of sub-division, and is then treated with a hot solution of sodium sulphide containing sodium hydrate. The extracting vessels should be worked in series. The electrolytic vats are of iron, and may be used as kathodes. The anodes should be of sheet-steel. Using a current density of 0·5 to 0·8 ampere per sq. decimetre, and an E.M.F. of 2 volts, the mercury can be separated from the sulphide solution without difficulty. The electrolyte can be used again for extracting fresh ore after addition of sulphur. J. B. C. K.

1241. *Electroplating the Hulls of Vessels.* (Elect. Engin. N.Y. 27. pp. 131–132, 1899.)—After a series of tests covering a period of four years, a favourable report has been rendered to the United States Government on T. S .Crane's system of copper-plating the hulls of vessels. The ocean-going tug *Assistance* was electroplated and launched in February, 1895. A short time ago she was docked and subjected to a critical examination; her bottom was absolutely free from marine growth of any kind.

The method of electroplating consists primarily in the use of flexible shallow baths, open at one side, and being made water-tight by suitable flexible packing at the edges. The baths are made flexible in order to follow the curvature of the vessel, and are supported against its side or bottom by tension ropes, screw shores, or magnets. The vessel forms the negative pole, the plating bath the positive; the plating is done in sections which slightly overlap, so as to form a continuous coating. In order that the density of the solution may be kept uniform, circulation is effected by letting the solution flow into the bottom, and out near the top, of the bath. A current rate of 7½ amperes per square foot and a potential difference of 1½ volts give a uniform, smooth, and adherent coating to the metallic surface of the vessel.

The whole bottom of a ship 400 feet long, drawing 20 feet of water, can be plated in eight or nine days, using about 55,500 pounds of copper. The tests were conducted by the well-known electrical engineer, A. A. Knudson, and the electro-chemist, W. J. Comly. The former says in concluding his report: "I have discovered so far nothing about this boat that could be considered as a serious objection to this method of copper-plating the bottom of an iron or steel vessel, and I believe this invention will have a very important future. I suggest that not less than one-sixteenth of an inch of copper plating should be allowed."

It is claimed that as much as £4,000 per annum is expended by various ships in the trans-Atlantic trade to overcome the added friction caused by fouling, while the cost of docking a big ship twice a year would nearly double the total loss as a penalty for unprotected bottoms. An iron vessel with a speed of 20 knots, if coated with copper, will have, it is calculated, a speed of 21 knots. A. S.

1242. *Electrolytic Vats.* **H. Becker.** (Ind. Électrochim. 3. pp. 13–14, 1899.)—A continuation of the notes previously dealt with (see 1899, Abstract No. 873). Vats in which mercury is used as kathode material in addition to those previously named, have been patented by Sinding Larsen, Kellner, Richardson, Vautin, Drake, Rosenbaum, Stoermer, Aret, Bell, Rhodin, and others. The author gives brief details of Kellner's German Patent 73224, and Kellner's English Patent 13722, of 1893, both designed to utilise the energy of the amalgam formed in the mercury cell.

Electrolysers for the production of the metal sodium in the pure state, or one of its alloys, are next described. Of this type are the electrolysers of Burghardt (12977, 1892), Grabau, Vautin (13568 and 20404, 1893) and Hulin. J. B. C. K.

1243. *Castner-Kellner Alkali Works.* **J. B. C. Kershaw.** (Elect. Rev. 44. pp. 509–513, 1899.)—This paper gives a history of the Castner-Kellner alkali process, together with some useful comparisons of the efficiency and cost of production of alkali and bleach by different methods.

After briefly describing the old Le Blanc process, the author gives a full account, with diagrams, of a Castner-Kellner cell. (See also 1898, Abstract No. 962.)

The plant already in use at Weston Point is of 2,000 H.P. capacity, whilst an extension of like size is in course of erection

With reference to the figures, no fresh information has been obtainable, but it is pointed out that the whole bleach output of the works has been sold until 1900 on very favourable terms, nearly thirty shillings higher than the current market price. Until, therefore, the old and new systems are competing on the same basis, it is difficult to gauge the exact additional profit which is realised by the electrolytic method. J. L. F. V.

1244. *Roberts' Electric Furnace.* (Zeitschr. Elektrochem. 5. pp. 340–342, 1899.)—The form of furnace protected by German Patent No. 100476, of July 28, 1897, is described at length. It is primarily intended for the manufacture of calcium carbide, but may obviously be used also for other purposes. In brief, the furnace consists of a rectangular vessel of sheet iron, with a hopper at one end of the cover and a flue at the other. The floor of the chamber consists of the upper side of an endless band of wire gauze, which is made to travel over roller supports by being stretched around a rotating drum at either end. The gauze is protected by a layer of asbestos. The carbon rods forming the electrodes are so pivoted at the hopper end of the furnace that they are free to move in a horizontal plane about their vertical axes. They may thus converge within the furnace so that their extremities are in contact, or they may be placed parallel, or of course at any intermediate angle of inclination. They are insulated from the end wall of the furnace through which they pass. In use, the carbon rods are first made to touch, a current is passed, the rods are then separated, and an arc is formed. Meanwhile the charge of powdered lime and carbon is fed through the hopper, carbide is formed between the poles, the current density is increased, the carbons are separated still further, and so on, until the rods are parallel and the arc is passing across the whole space between their ends. The gauze belt is kept in motion in such a direction that the charge from the hopper is conveyed to the zone heated by the arc. The carbide is thus removed as fast as it is formed, and fresh raw charge takes its place. As the carbide is formed and fused only in the zone between the ends of the electrodes, there are left layers of unaltered charge above and below it, the carbide itself forming a continuous cake. This cake is moved steadily forward with the rest of the charge to the cool end of the furnace, where it is broken up, and the unaltered mixture, in the pulverulent condition, is collected separately and again conveyed to the charging hopper. A modification of the furnace is described. W. G. M.

GENERAL ELECTRICAL ENGINEERING.

1245. *Pescetto Accumulators.* (Elect. Rev. 44. pp. 625–626 and 671–672, 1899.)—Three forms of this accumulator are constructed, suitable for lighting, for the distribution of electric energy, and for traction purposes respectively; and a *résumé* is given of the performance of the various batteries, which appear to be very efficient, under different conditions as regards rate and time of discharge. The grid is composed of an alloy of lead, which is said to be unattacked by sulphuric acid, and a superior physical condition of the active oxides is brought about by admixture with a substance, here termed *ulmate of ulmin*, which is obtained by the action of boiling dilute sulphuric acid on sugars. (See also 1898, Abstract No. 431.) N. L.

1246. *Accumulators for Motor-Cars.* **J. Reyval.** (Écl. Électr. 18. pp. 86–88, 1899.)—A detailed description, in tabular form, of five types of the Pisca accumulator. The specific constants of the larger types, per kilogram of total weight, are: capacity, 6·6 ampere-hours; energy, 12·6 watt-hours; power, 4·2 watts. The normal discharge is 2·2 amperes per kilogram for three hours, the E.M.F. 1·9 volts, and the specific weight 234 kilograms per kilowatt or 78 kilograms per kilowatt-hour. N. L.

1247. *Accumulator Switch.* **H. Müller.** (Elektrotechn. Ztschr. 20. pp. 152–154, 1899.)—The switch here described and fully illustrated is designed to carry 1,800 amperes. The "charge" and "discharge" sections each comprise a carriage actuated by a feed-screw and bearing two double-brush bridges. One of these bridges connects the accumulator terminals with a longitudinal contact-bar having teeth which extend between successive terminals and are equal in width thereto. The other bridge connects a similar parallel set of terminals and contact-bar, which is so arranged that its accumulator terminals are opposite to the teeth on the first-mentioned contact-bar. The second contact-bar is connected to the other bar and to the dynamo, or to the line, through a suitable resistance, to prevent short circuiting of the cells during regulation. Auxiliary switches actuated by spur-gearing from the feed-screws serve to break the circuit of each cell, as it is cut out of circuit, before the main bridge-piece has left the terminal of the cell; by this means sparking is confined to the auxiliary switches, and the life of the main switch is thus rendered practically unlimited. C. K. F.

1248. *A New Condenser.* (Elect. Engin. N.Y. 27. p. 134, 1899.)—This is a description of a condenser invented by C. S. Bradley, of Avon, N.Y. In its construction two conducting wires are wound on a bobbin, preferably arranged in alternate layers, one of the wires being covered with thread having a comparatively low specific inductive capacity, the several convolutions of which are separated from one another so as to leave open spaces between them: the other wire is bare. The wires may be coated, before winding, with the material which is to constitute the dielectric of the condenser, steareate of lead, and afterwards immersed in a hot bath of the same. The ends of the covered conductor are connected to one terminal, and those of the bare wire to a second one; these form the terminals of the condenser. On the same general principle it may be formed of a plurality of wires wound in close relation, so as to lie adjacent to one another, one of the wires being wound with an open spiral of insulating material to form a spacing medium which will prevent mechanical contact of the two metallic surfaces with one another. W. G. R.

1249. *Electricity in a Medical Clinic.* (Amer. Electn. 11. pp. 57–62, 1899.)—This is a description of the electrical plant at the Polhemus Memorial Clinic, Brooklyn, N.Y., where electricity is used for various medical purposes as well as for working the ventilating fans. W. G. R.

1250. *Mechanical Applications of Electricity.* **G. Richard.** (Écl. Électr. 18. pp. 281–290, 1899.)—This is an illustrated descriptive article on electrically controlled railway signals and clocks. W. G. R.

1251. *Relative Merits of Glass and Porcelain as Insulators.* **A. Fleury.** (Électricien, 17. pp. 118–121, 1899.)—Hitherto porcelain insulators have been almost exclusively used for aerial conductors, on account of the well-known hygroscopic nature of glass. Recently, however, attempts have been made to produce insulators of a coarse kind of glass—the exact composition of which is a manufacturer's secret—which do not condense any film of moisture on their surface. Experiments carried out with such insulators appear to show conclusively that they are much superior to porcelain; the author believes that they have a large field of usefulness before them. A. H.

1252. *Maxim's Method of Making Incandescent Lamp Filaments.* (Elect. Engin. N.Y. 27 pp. 174–175, 1899; U.S.

Patent No. 618704.)—In order to increase the resistance of incandescent lamp filaments for high-voltage lamps, H. S. Maxim mixes with the carbon of which the filaments are composed, diamond dust, or a species of carbon closely resembling the diamond, and manufactured by the following process: In a cylindrical steel vessel lined with a suitable refractory material and closed at each end by a screw plug bearing a carbon-pencil in a water-jacketed holder, there is placed carbonic acid in a liquid or solid (snow) form, together with carbon, or a hydrocarbon, such as gasolene. On heating the mixture by means of the voltaic arc, the CO_2 and the hydrocarbon are decomposed, CO being formed and a great pressure thereby generated in the vessel. By the continuance of such high pressure and temperature a very hard and crystalline form of carbon is produced, which after its removal from the vessel can be crushed into extremely fine powder. This powder is mixed with suitable vehicles, such as tar, pitch, or sugar, and then moulded with filaments which are "retorted" and "flashed" in the usual manner. C. K. F.

1253. *The Track Circuit for Railroad Signalling.* **C. C. Anthony.** (Elect. World and Elect. Engin. N.Y. 33. pp. 540–542, 1899.)—The track circuit, which is much in use in America for the automatic control of signals by trains, consists of the two lines of rails of a portion of the track separated from the adjoining rails by insulating rail joints, with the poles of a battery connected to the opposite rails at one end, and the coils of an electro-magnet at the other. The line resistance is very low; the insultation resistance is also very low and variable, and the current in the magnet coils is cut off by shunting, when the rails are connected by the wheels and axles of a train, and not by opening the circuit. With low insulation and shunt resistances it is impracticable to use a high potential or large current. It follows that the track circuit must control electric signal appliances through a comparatively delicate relay.

The relay should be sensitive and efficient. When such a relay has been designed, the relay or battery resistance should be as high as it can be made, with due regard to the necessary provision for the closing of the relay under the most unfavourable conditions expected. Any possible small economy of current that might be secured by a particular arrangement is quite subordinate to the effectiveness of the shunt. So, too, a maximum of energy at the relay from a given battery is not an essential requirement; if the required amount of energy is available under the most unfavourable conditions nothing more is necessary. On the other hand, waste of current on the shunted circuit must be kept within reasonable limits; but the considerable battery resistance required for this purpose is equally useful in making the shunt effective. W. G. R.

1254. *Interior Wiring Systems.* **L. B. Chubbuck.** (Canad. Elect. News. 9. pp. 43–46, 1899. Read before the Engineering Society of the School of Practical Science, Toronto.)—A review of the chief systems used in America. Most work is done with concealed insulated wires run on porcelain knobs under floors or between walls, and in porcelain tubes embedded in the plaster. The modern fireproof construction, however, leaves no space for such work: hence the evolution of conduit systems. Two kinds of iron armoured conduit are used, one lined with treated paper and the other coated with enamel inside and out. The smooth surface of the latter facilitates drawing-in; the former prevents "sweating." To ensure good workmanship no draw-in cords should be put in during erection; after completion a $\frac{3}{16}$-inch steel tape should be pushed through. An 80-foot run with four bends is not an excessive length to thread.

E. H. C.-H.

1255. *Paper Telephone Cables.* (Elect. Rev. 44. pp. 535–537, 1899.)—The specific inductive capacity of gutta-percha is 2·46, of rubber 2·34, of paper nearly unity. The average capacity of a telephone cable should be 0·080. The capacity of an india-rubber cable (presumably similar and of No. 20 S.W.G.) is 0·290 Preference is given to a twisted strip method of covering. The jointing of multiple wire cables, drawing into terminal boxes, drying by the air-pump at a pressure of 15 lb., and localising faults by the issuing air are described. M. O'G.

1256. *Izambard Process of Printing by X-Rays.* (Elect. Engin. N.Y. 27. p. 61, 1899.)—In this process a number of sheets of sensitised paper are piled one on the top of the other, and between the pile and the source of X-rays is the copy, which is printed or written in ink made in part of finely divided metallic or calcareous powder; bronze, copper, white lead, or white zinc may be used; as a writing ink, white lead in a solution of gum; as a type-writing ink, metallic powder mixed with boiled linseed oil. The limit of thickness of the pile that can be printed at one exposure is reached when the rays are distributed so as to distort the image; this limit is about two inches. C. K. F.

1257. *Printing by Means of X-Rays.* **F. S. Kolle.** (Elect. Engin. N.Y. 27. pp. 77–79, 1899.)—The process here described is an improvement on the Izambard process. A number of inks are described suitable for writing, printing, type-writing, &c. A feature of the improved process consists in making the paper in a continuous strip, and sensitising it in page-sections alternately on opposite sides in such a way that, when folded to the proper size, each section will still retain the features of a single sheet. For printing on both sides of the paper, the page-sections are sensitised in strips with intermediate spaces as in the Izambard process, the spaces on one side of the paper registering with the sensitised strips on the other side. Information is also given as to printing frames, developing apparatus, and other details. C. K. F.

1258. *Power from Blast Furnaces.* **A. Witz.** (Écl. Électr. 18. pp. 401–407, 1899.)—Recent improvements in blast furnaces have resulted in a great increase in the production of pig-iron and a diminution of the fuel used. In America there are furnaces giving a daily output of 700 tons for an expenditure of three-quarters of a ton of fuel per ton of pig-iron. Of the heat developed by the combustion of the fuel only about 29 per cent. is utilised in effecting the necessary chemical changes, and many attempts have been made to utilise the waste heat. In evaporating water in a steam boiler about 22 cubic metres of blast furnace gas are required per H.P. hour. The author has found that the calorific value of blast-furnace gas is on the average 1,000 calories per cubic metre, so the above consumption represents a thermodynamic efficiency of about 3 per cent. In other words, utilising the waste heat to generate power by steam engines and boilers, the best one may hope to obtain is about 450 I.H.P. for a 100-ton furnace.

Gas engines work with an expenditure of two to three cubic metres of poor gas, and in 1894 Thwaite first made the attempt to utilise blast-furnace gas in a gas engine. His first experiment at Wishaw, Scotland, was very satisfactory. The author traces briefly the history of the utilisation of the gas in this manner, gas engines up to 600 H.P. being used; while at Seraing there will soon be in operation a two-cylinder engine of 1,000 H.P. The author is of opinion that a combustion motor would be better than an explosion motor for the utilisation of blast-furnace gases, but this is a type of engine that has yet to be created, and at present the only engines employed have been of the well-known explosion type. The power thus available is more than sufficient for all the operations required at an ironworks, and when the geographical conditions are favourable the excess may be conveniently transmitted and distributed. (See also 1898, Abstracts Nos. 991, 992, and 993.) A. S.

1259. *Elevators for Central London Railway.* (Engineering, 67. pp. 273–276 and 306–307, 1899.)—The lifts selected for the stations of the Central London Railway are made and designed by the Sprague Electric Company, New York. One of the conditions to be complied with was that with an average total of 20,000 single trips per day of 67 feet mean rise, and with current at 1d. per Board of Trade unit the elevators must be worked for three years at a cost not exceeding £1 per 1,000 trips. The diameters of the shafts in which the elevators work vary from 18 feet to 30 feet, three cars being placed in the larger shaft. Details of the construction and specification of the cars are given. The hoisting machinery is extremely simple and completely self-contained. Side frames mounted on a heavy cast-iron bedplate carry bearings for the drum and idler shafts, and form oil tanks in which the worm-gear is enclosed. Directly coupled to the worm-shafts are the four-pole shunt-wound iron-clad motors, which at 470 revolutions per minute give a lift speed of 200 feet per minute. Each motor drives a shaft on which are fixed right-handed and left-handed worms gearing with two worm-wheels, lateral thrust on the drum-bearings being thus done away with, and the thrust of one worm being balanced by that of the other. As a safety device the usual Sprague jaw clamps are used, specially modified for the conditions. Each safety catch is calculated on the basis of a loaded car weighing 40,000 lb., having to be supported by friction only between the clamps and the guide rails, the assumed frictional coefficient being 15 per cent. As an additional safeguard oil buffers are placed on all cars and counter-weights. These are large dashpots, with plungers, having tapering grooves on their external surfaces, which allow the cars to settle rapidly when the buffer first comes into operation, the settlement becoming slower as the grooves narrow.

The experimental lift erected at Notting Hill Gate under the conditions of the contract has been subjected to rigorous tests with most satisfactory results. A. S.

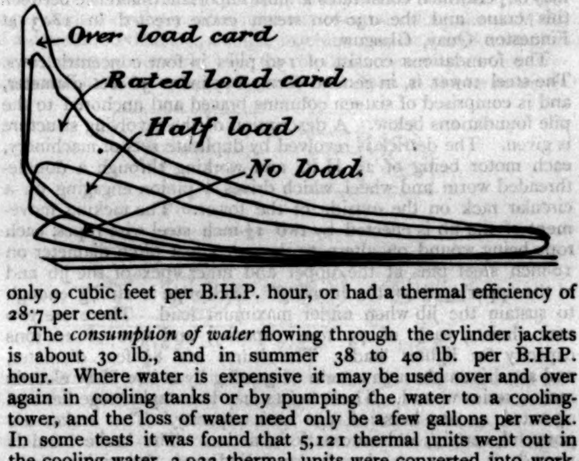
1260. *Recent Developments in Gas Engines.* **E. Ruud.** (Elect. Engin. N.Y. 27. pp. 255–257, 1899.)—Large gas engines work on the "Otto" or "Beau de Rochas" cycle, and fall into two classes, depending on the mode of regulating the speed:—

1. In the "hit and miss" governing type, chiefly in use, one or more charges of gas are cut out altogether. Where uniform speed is required, as in electric lighting, the "hit and miss" gas engine must have heavy fly-wheels, and a heavy balance wheel is usually mounted on the jack shaft. The variation in voltage on a 100-volt circuit is generally from 3½ to 4 volts during the cycle. When the engine takes in a few charges successively the voltage is steady and rising, but when the engine omits one or more charges a momentary variation in speed is the result, and fluctuation is apparent in the lights. The loss of power by the two belts is about 7 per cent., and by the jack shaft 3 per cent., making a total of 10 per cent. taken by the extra machinery. One advantageous feature of this type of gas engine is that the charge is always ignited under the same pressure, and hence the actual work done by the exploding gases in a cycle is practically the same for full load as for no load.

2. In another type of gas engine, adapted for electric lighting, the speed regulation is said to be as good as that of a first-class steam engine. The armature is on the crank-shaft direct-coupled

or directly belted. The mode of governing is similar to that of the steam engine. All charges are proportioned to the load. If the entire load is suddenly thrown off at once, which seldom occurs, there is one heavy charge already in the engine, although the governor acts instantly, and there may be another under way partially reduced by the action of the governor. This tends to speed up the engine slightly above the normal, but it is reduced by the fly-wheels. The indicator diagrams give an idea of the governing action of a Westinghouse gas engine of this type.

The *gas consumption* in all engines varies with the kind of gas used, and also with the size of engine up to certain limits. The average in the Westinghouse gas engine, from 20 H.P. upwards at everyday work, is 10·5 to 12 cubic feet of Pittsburg natural gas per B.H.P. hour. The heating value of natural gas, found by the Junker calorimeter, is about 1,000 B.Th.U. per cubic foot. That is, the engine requires 10,500 to 12,000 B.Th.U. for each B.H.P. hour, giving a thermal efficiency at the shaft of 25·4 and 21·3 per cent. A special engine of 125 B.H.P. used only 9 cubic feet per B.H.P. hour, or had a thermal efficiency of 28·7 per cent.



The *consumption of water* flowing through the cylinder jackets is about 30 lb., and in summer 38 to 40 lb. per B.H.P. hour. Where water is expensive it may be used over and over again in cooling tanks or by pumping the water to a cooling-tower, and the loss of water need only be a few gallons per week. In some tests it was found that 5,121 thermal units went out in the cooling water, 2,922 thermal units were converted into work, so that 2,957 thermal units must be lost by the exhaust and radiation.

In the spring, 1898, an engine of 650 B.H.P. was completed in the works of the Westinghouse Machine Company. This engine has three vertical cylinders, and speed of 150 revolutions per minute. Another three-cylinder gas engine is in hand, designed to give 1,500 B.H.P. at 100 revolutions per minute on 8½ cubic feet of natural gas per B.H.P. hour, or 8,500 B.Th.U. per B.H.P. hour, that is, a thermal efficiency of 30 per cent. at the shaft.

Such an engine will run every day on less than 1 lb. of coal burned in a producer gas plant per B.H.P. hour, including banking of fires and similar losses. W. R.

1261. *150-ton Electric Jib Crane.* **W. A. Post.** (Elect. Engin. N.Y. 27. pp. 134–137, 1899. Abstract of paper read before the Society of Naval Architects and Marine Engineers.)—Early in 1896 the Newport News Shipbuilding and Dry Dock Company resolved to provide a crane capable of lifting the heaviest single weight likely to be met with in the probable development of modern ships. Careful consideration of all the requirements led to the adoption of a 150-ton revolving crane electrically operated, mounted on a steel tower on pile foundations. The jib is capable of having its outer end raised or lowered, so that the derrick may operate on weights lying within two concentric circles of 207 feet and 88 feet diameters respectively. The feature of varying the radius at which the hoisting may be performed constitutes a most important difference between this crane and the 130-ton steam crane erected in 1893 at Finneston Quay, Glasgow.

The foundations consist of 150 piles in four concentric rows. The steel tower is, in general form, a cylinder 36 feet diameter, and is comprised of sixteen columns braced and anchored to the pile foundations below. A description of the revolving structure is given. The derrick is revolved by duplicate sets of machinery, each motor being of 20 H.P., and working through a double-threaded worm and wheel, which drives a pinion engaging on a circular rack on the outside of the tower. The racking movement of the jib is effected by two 1¼-inch steel wire ropes, each rope being wound on alternate sheaves 5-feet pitch diameter on 10-inch steel pins at the upper and inner apex of the jib and at the upper apex of the housing. Each rope is strong enough to sustain the jib when under maximum load. There are two main hoists, each of 75 tons capacity, and one of 20 tons capacity for lighter loads. The drums are 8½ feet diameter, and are driven through a train of gearing by a 100 H.P. electric motor, series wound. These hoists may be coupled together and operated as one hoist of 150 tons capacity. The brakes are powerful, certain, and automatic in action. The brake band is wound 4½ times round a brake cylinder on the pinion shaft, and is of wrought-iron 1 inch thick, 5 inches wide at one end, and tapering to 1¼ inches at the other. The broad end is firmly anchored, the narrow one secured to a lever carrying a weight of 200 lb. When lowering, the rotation of the brake cylinders is towards the small end of the band, so that the friction produced by the weight causes the band to wind tight on the cylinder and stop rotation. To release the brake it is only necessary to lift the weight, which is done by means of a wire connected to a lever in the operating-house. In hoisting, the brake releases itself. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

1262. *European and American Dynamo Design.* **B. A. Behrend.** (Elektrotechn. Ztschr. 20. pp. 174–175, 1899.)—The most striking feature pointed out by the author is the small number of poles and large current per armature conductor used by the Westinghouse Company. He cites the case of a 1,500-kilowatt generator (550 volts, 2,730 amperes) with only 14 field poles and consequently 195 amperes per armature conductor. Sparkless commutation is obtained by strongly saturating the laminated field-poles, so that armature reaction is necessarily small. A. H.

1263. *Subdivision of Dynamo E.M.F. and Excitation at Half P.D.* **A. Sengel.** (Écl. Électr. 18. pp. 188–193, 1899; also Elektrotechn. Ztschr. 19. p. 544, 1898.)—The first part of the paper deals with the various methods of subdividing the E.M.F. of a dynamo so that, *e.g.*, a single machine may be used for supplying a three-wire network. In the methods described, which are illustrated in the accompanying diagrams (Figs. 1–4), one or more points in the armature winding are connected to slip-rings, and by a suitable arrangement of choking coils interposed between the balancing wire and the slip-rings satisfactory working may be secured. Fig. 1 is not to be recommended, as the arrangement is not entirely free from fluctuations in the potential of the balancing wire. Figs. 2 and 3 give satisfactory results. Fig. 4 represents a device due to Ettingshausen; between the slip-ring and two diametrically opposite points in the winding are interposed two auxiliary windings, each covering half the core, and each containing a number of conductors equal to half that in the corresponding main winding.

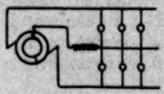


FIG. 1.

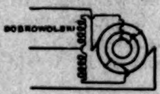


FIG. 2.

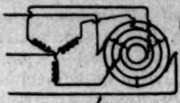


FIG. 3.

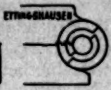


FIG. 4.

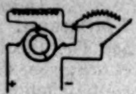


FIG. 5.

The second part of the paper is concerned with the methods of shunt-excitation at half the terminal P.D. The arrangement proposed by the author for a short-wound motor is sketched in

Fig. 5. The advantage of such a device lies in the fact that a wire of double the sectional area may be used for winding the shunt, so that the cost of the field winding is considerably reduced.

A. H.

1264. *Armature Design.* **C. Westphal.** (Elektrotechn. Ztschr. 20. p. 118, 1899.)—The author deduces the two following formulæ for the interconnection of the armature conductors in multipolar dynamos :—

$$y=\frac{1}{p}\left(\frac{s}{c}\cdot b\pm a\right) \qquad (1)$$

$$y_1+y_2=\frac{1}{p}\left(\frac{s}{c}\cdot b\pm 2a\right) \qquad (2)$$

where $2p$ = the number of poles; s = the number of inducing bars or conductors around the armature; c = the number of these bars in each section; b = a whole number; $2a$ = the number of circuits in parallel with each other. In formula (1), which relates to the case where the beginning and end of each element lie on one and the same end face of the armature, y = the "pitch," or number of bars which lie between the commencements of two successive elements in the winding. In formula (2), which relates to the case where the beginning and end of an element lie on different ends of the armature, y_1+y_2 = the double pitch. Reference is made to the work of E. Arnold on *Ankerwickelungen.* C. K. F.

1265. *Sayers' Third-Brush Method of Dynamo Regulation.* **C. P. Feldmann.** (Elektrotechn. Ztschr. 20. pp. 232–235, 1899. See The Electrician, 41. p. 358, 1898.)—Some interesting curves are given, showing the behaviour of a machine under this mode of excitation. No difficulty appears to arise in over-compounding a machine, and there is no sparking trouble due to the unsymmetrical distribution of the armature current through the windings. Objections might possibly be raised from a purely mechanical point of view—if the third brush should get damaged, or drop out, or if the commutator were thrown out of truth, the machine might lose its field. A. H.

1266. *Contact-Resistance of Brushes and Temperature of a Commutator.* **E. Arnold.** (Elektrotechn. Ztschr. 20. pp. 5–7, 1899.)—In this paper curves are given showing (1) the variation of contact-resistance with current density at different angular velocities; (2) the variation of contact-resistance with angular velocity at different current-densities (these curves present the peculiarity that, as the angular velocity increases, the contact resistance gradually rises to a maximum and then decreases); (3) the variation of contact-resistance with pressure at different angular velocities. The losses by sparking, by eddy currents, and by friction are also investigated. Methods of calculating the dimensions of commutators so that a given rise in temperature shall not be exceeded, are also given. Reference is made to some researches of G. Dettmar on contact resistance, published in the Elektrotechn. Ztschr. Heft. 16. 1898. C. K. F.

1267. *Balancing of Armatures.* **C. W. Hill.** (Elect. Rev. 44. pp. 546–547, 1899.)—The best way of testing the balancing of armatures is to test with that force which it is desired to compensate, that is to say, the centrifugal force itself. To do this the armature should be mounted in bearings which are free to move, then while the armature is running the heavy side can be found with a piece of chalk and counterweights adjusted on the opposite side until the cessation of movement of the bearings shows that the centre of gravity coincides with the axis of the shaft. W. G. R.

1268. *Theoretical Dynamo Without Brushes.* **A. Campbell.** (Elect. Rev. 44. pp. 581–582, 1899.)—Let PMQN in Fig 1 be a Wheatstone's bridge in which B is a battery, and let the four arms be of equal non-inductive resistance, but two of them, PM and MQ, of pure bismuth. Now let a strong magnetic field cut alternately the two bismuth arms. This will cause an alternating potential difference between P and Q.

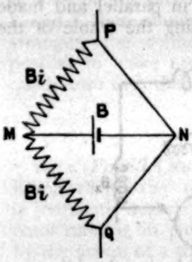


FIG. 1.

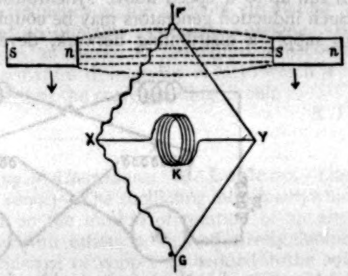


FIG. 2.

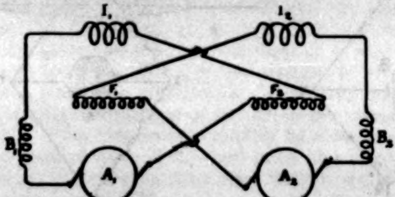
In Fig. 2 the battery is replaced by a coil, K, with its plane perpendicular to the plane of the paper. If the magnetic flux now moves downwards from F to G, and be followed at a distance equal to FG by a series of similar fluxes, an alternating E.M.F. will be set up in the coil K. Owing to the action of the bismuth arms, however, a unidirectional potential difference will be produced from F to G, and a rectified current may be taken from these points.

The author extends this principle by making all four arms of bismuth. W. G. R.

1269. *Rotary Balancers.* **C. B. Davey.** (West. Electn. 24. pp. 154–155, 1899.)—The best arrangement for a balancer is that of a single machine having two windings on its armature and two commutators. This gives the best results with a minimum of trouble, the losses also being the lowest possible. W. G. R.

1270. *Dynamo-Electric Machinery.* **C. F. Guilbert.** (Écl. Électr. 18. pp. 298–304, 1899.)—This is an article on the various attempts to reduce magnetic leakage in dynamos. W. G. R.

1271. *Induction Generators.* **M. Leblanc.** (Écl. Électr. 18. pp. 161–167 and 376–379, 1899.)—The author describes and works out the theory of a special form of single-phase induction machine in which the six-pole inducing winding is carried by the rotor, while the induced two-phase winding is embedded in the stator. As is well known, such a machine when started will go on running as a motor at a speed a little below that of synchronism. If run up to a speed above synchronism it acts as a generator. Such induction generators may be coupled in parallel and made to supply a distributing network, developing the whole of the load current; but they are incapable of developing the idle component of the current, so that this latter must be supplied by an alternator of the usual type. Induction generators may also be coupled in series, and are in that case capable of developing the whole of the E.M.F. component which is in phase with the current; but the component in quadrature with the current must be supplied by a special source. Whether coupled in parallel or in series, induction generators need not run synchronously: in this respect they resemble continuous-current machines, those



which run faster taking a larger share of the load. These theoretical deductions have been fully verified experimentally on a large scale.

In order that an induction generator may be capable of developing currents in quadrature with the E.M.F., it is necessary to fulfil the condition $\lambda L < M^2$, where λ is the inductance of the induced or short-circuited winding, L the inductance of the inducing winding, and M the mutual inductance of the two windings. Normally, of course, λL is always greater than M^2. The author considers two methods of artificially decreasing λ so as to make $\lambda L < M^2$, and thus enable the induction machine to develop idle as well as load currents. The first method consists in using a capacity to balance the inductance λ; ordinary condensers are not suitable for this purpose, as the frequency of the currents is extremely low. Electrolytic condensers, on the other hand, may be used with advantage; they may be considered as ordinary condensers of enormous capacity, which break down as soon as the terminal P.D. exceeds 1·4 volts; they will keep cool so long as the current density does not exceed the limits used in charging accumulators. The second method consists in using a special form of exciter, the arrangement of connections for a two-phase generator being shown in the accompanying figure. The exciter consists of two small continuous-current dynamos, whose armatures, A_1 and A_2, are mechanically coupled. The fields are laminated, and are provided with two windings: F_1 and F_2 are the ordinary field windings, while B_1 and B_2 are balancing windings which counteract armature reaction. I_1 and I_2 are the induced windings of the two-phase induction machine. On account of the very low frequency of the currents circulating in I_1 and I_2 there should be no difficulty as regards sparking. By arranging the connections as shown in the figure it becomes possible to make each armature develop an E.M.F. which is in quadrature with the current in the corresponding circuit.

A. H.

1272. *Parallel Running of Alternators.* **M. Leblane.** (Écl. Électr. 18. pp. 123–128, 1899.)—The oscillating movement, which is frequently superposed on the motion of rotation of an alternator running in parallel with others, is very effectively damped by the action of a squirrel-cage of copper embedded in the pole-pieces. A large fly-wheel alternator constructed on this principle is illustrated and described. (A full description will be found in The Electrician, 38. p. 210, 1896; or El. Eng. 20. p. 598.)

A. H.

1273. *Parallel Running of Alternators.* (Elect. Engin. 23. pp. 404–405, 1899; also Elekt. Runds.)—The speed of an engine when loaded is more uniform than when running light. Hence

if an incoming alternator, which is properly synchronised but is running light, is connected across the 'bus bars, it will draw a heavy current on account of the much greater momentary variations of its speed than those of the loaded machines. In order to prevent this, artificial loads consisting of resistance wires have in some cases been used; these, however, are generally somewhat expensive. The method recently patented by G. Dettmar consists in using a magnetic brake, which acts upon the fly-wheel of the driving engine: by loading the engine the required degree of uniformity in speed may be reached, and the incoming machine thrown into parallel with the others without any trouble.
A. H.

1274. *Relative Dynamo and Motor Capacities.* **A. D. Adams.** (West. Electn. 24. p. 243, 1899.)—With motor and dynamo ratings, each based on the same winding losses, and, consequently very nearly the same temperature rise, the motor capacity of any machine may be found from its dynamo rating by adding to this rating twice the watts in the shunt-winding and then multiplying this sum by the efficiency of the dynamo, provided the motor and dynamo ratings are based on the same voltage at the brushes. If, as is frequently the case, the volts at the motor are less than the volts on which the dynamo rating is based, then the motor capacity as found above should be reduced in the proportion of the volts at the motor to those at the dynamo brushes. Were the above relation between dynamo and motor ratings generally followed, a variation in the ratio between machines would indicate at once a variation in magnet-coil loss, or efficiency, or both. W. G. R.

1275. *Induction Motors.* **E. Wilson.** (Instit. Elect. Engin. Journ. 28. pp. 321–355. Discussion, pp. 356–363, 1899.)—This is an account of some experiments on a 15 H.P. induction motor. The object of the experiments is to investigate the armature reaction and starting torque, as the external resistances placed in the rotor circuits are varied. The motor has a three-phase winding. The results obtained show that as the rotor resistances are increased the phase differences of the induced electromotive forces and currents increase up to the point of maximum torque; after this the effect at 52 periods per second is to slightly increase the phase difference, but at 95 periods per second the phase difference is decreased. An examination of the tables given shows that the armature reactions are very violent when the rotor is short-circuited at start. The torque fluctuates between positive and negative values; the effect is a differential one: on the whole there is a small positive torque. When the rotor resistance is very large the induced electromotive forces and currents are practically in phase, and the torque is small because the currents are small. As the rotor resistance is diminished, a lag of current behind electromotive force ensues, but the current increases as also the torque. This goes on till the torque reaches a maximum value. On still further diminishing the rotor resistances the torque decreases.

The paper includes eighteen tables of experimental data.

In the discussion, **W. M. Mordey** inquired how it is that waste field involves dissipation of energy, which the author answered by defining the waste field to be that which did not interlink both circuits.

Field pointed out that the air-gap in the motor was unnecessarily large. W. G. R.

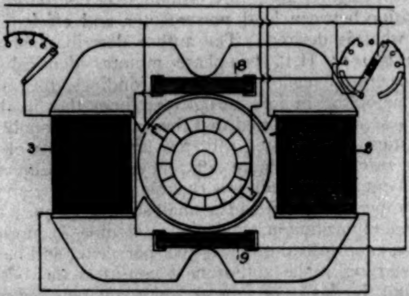
1276. *Induction Motors with Large Starting Torque and Overload Limit.* **T. Marcher.** (Elektrotechn. Ztschr. 20. pp. 235–238, 1899.)—The first step in the design of an induction motor is the determination of its dimensions, which may be obtained by using the formula given by Kapp, viz., $H.P. = K \cdot d^2 l n$, in which d stands for the diameter, l for the length (in cms.), and n for the revolutions per minute; K being a constant which depends on the frequency, and which for a frequency of 50 ∿ varies from $0{\cdot}5 \times 10^{-6}$ to $0{\cdot}7 \times 10^{-6}$. If next, a certain value of B is assumed, the number of turns per phase on the stator coils may be calculated. But the behaviour of a motor designed after this fashion may not be satisfactory, as the relation between load, power-factor, and efficiency may be far from what is desired. The author describes some experiments on two 15 H.P. two-phase motors, identical in every respect, except as regards the stator windings, the number of turns in one of the motors being 1·34 times that in the other. Tests of these motors showed that they possessed totally different characteristics. The motor with the larger number of turns on the stator reached maximum efficiency and maximum power-factor at about normal load, was capable of standing an overload of about 50 per cent., and had a small starting torque; the other motor reached maximum efficiency at double its normal load, could stand an overload of over 300 per cent., and had a large torque at starting. The author next considers the best plan of setting about the design of motors which are required to furnish a large starting torque and be capable of standing a heavy overload (conditions which must be fulfilled by traction motors). To secure these results, the effective impedance of the motor must be kept low. He recommends the manufacturer to carefully measure the effective resistance $[\text{watts} \div (\text{current})^2]$ and effective impedance (P.D./current) at various loads for several sizes of motors which have been found to fulfil the required condition. By plotting the values of the effective inductance, when the motor is running light, the inductance L of any intermediate size of a similar type of motor may be found. The number of turns S in the stator windings is then found by using the formula $L=4\pi\left(\frac{S}{2}\right)^2/(10^9R)$, where R stands for the reluctance of the magnetic circuit; R is determined from the known dimensions of the motor (K being known). In order to maintain the resistance of the rotor at a low value, the author recommends the use of rotors provided with a three-phase winding in connection with two-phase stators, since in that case a greater number of conductors is active at any instant than with a two-phase rotor.

A. H.

1277. *Induction Motor Diagrams.* **C. C. Hawkins.** (Electrician, 42. pp. 866–869, 1899.)—This concludes a series ot articles on the graphical study of induction motors. (See 1899, Abstract No. 915.)

W. G. R.

1278. *Controlling Motor Speed.* **F. A. Johnson.** (Elect. World and Elect. Engin. N.Y. 33. pp. 556–557, 1899.)—The author describes a method, due to himself, of controlling the speed of motors, which consists in maintaining a strong and practically constant magnetic field at the pole-tips, where such is needed for sparkless commutation, while the magnetism of the remainder of the pole-face is varied to control the speed of the motor. One way of accomplishing this is illustrated in the accompanying figure. The coils, 8, 9, are so placed as to send lines of force through the centres of the pole-pieces, and their effect on the pole-tips is slight. Now, if a current, variable at will in direction and intensity, be passed through these coils, a wide range of speed may be obtained without sparking at the brushes. For, while the total flux will be greatly varied, the field in which the armature coils undergo commutation will remain practically constant.



W. G. R.

1279. *Transforming Single-Phase to Polyphase Currents.*—(Elect. Engin. N.Y. 27. p. 133, 1899.)—A method of deriving two or more alternating currents differing from one another in phase from a source supplying single-phase currents has been devised by H. A. Wagner, of St. Louis. The accompanying figures show how this is accomplished.

In Fig. 1 AD represents in magnitude and direction the electromotive force of a source, such as the secondary of a transformer, CD the electromotive force across the terminals of an inductance coil, forming a derived circuit differing in phase from the electromotive force AD by the angle ADC, and AC the resultant electromotive force across the terminals of a working circuit derived from the source AD and made to differ from it by the angle CAD through the effect of the inductance CD.

Fig. 1.

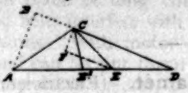


Fig. 2.

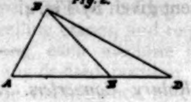


Fig. 3.

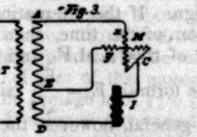


Fig. 4.

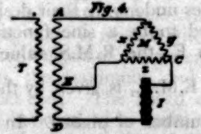
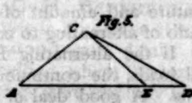


Fig. 5.



If another circuit is connected from the point C to some point E on AD, an angle ACE is formed with the circuit AC. This angle represents the difference of phase between the derived circuits AC and CE. The point E may be moved in either direction along AD to any other position as E', and the phase relation of CE, as well as its relative electromotive be altered as desired. If there is no self-induction in the circuit AC, it will assume the position AB at right angles to BD, and the relative phase angles and magnitudes then acquired by the different circuits are shown in Fig. 2. The flow of a comparatively large amount of current in a derived circuit such as CE will cause a slight decrease in the angle CAD by the nearer approach of C to D. This can be corrected by increasing the inductance CD, or the phase relations between AC and CE can be retained by moving the point of connection E.

Fig. 3 shows the application of the principle to the operation of a two-phase motor. T is a transformer with secondary coil AD. M is a motor with its two sets of coils, x and y, joined at C and with their other terminals connected, one to A and the other to E, and I an inductance connected between C and D.

Fig. 4 represents a three-phase motor M with sets of coils, x, y, and z.

Fig. 5 shows graphically the phase angles obtained in the arrangement given by Fig. 4. W. G. R.

1280. *Rotary Converters.* **Aliamet.** (Electricien, 17. pp. 114–118, 1899.)—The paper is concerned with general considerations regarding the action of converters, and with the principles underlying their design. If the alternating E.M.F. be supposed to be a sine function of the time, then the relation between E_a, the R.M.S. value of this E.M.F., and E_c, the continuous E.M.F., is given by the formula $E_a = \frac{E_c}{\sqrt{2}} . \sin \frac{\pi}{n}$, where n is the number of phases. In general, however, the sine law is not fulfilled. Further, if the converter be used for transforming alternating into continuous currents, the form of the P.D. wave will depend on the nature and amount of the load fed by the network, so that the ratio of alternating to continuous voltage will not remain constant. If the alternating P.D. is kept approximately constant for all loads, the continuous P.D. may undergo considerable fluctuations. A good deal of trouble may arise on account of sparking at the commutator if the converter is a continuous-to-alternating one, and is working on an inductive load; this sparking is due to the lag between P.D. and current. If the load changes from a non-inductive to an inductive one, violent sparking may take place without any apparent reason. All these difficulties have been largely overcome in the most modern types of converters; the main improvements consisting in largely reducing the amount of copper on the armature, in increasing the number of commutator segments, and in using large air-gaps and working at a high gap induction. These changes are, of course, accompanied by a corresponding increase in the cost and size of the machine, so that a modern rotary converter, if used simply as a continuous-current generator, would give a very low output in comparison with dynamos of usual construction. If the output of a converter as a continuous-current dynamo be denoted by unity, then on the basis of the same rise of temperature its outputs as a converter would be: Single-phase, 0·85; three-phase, 1·34; quarter-phase, 1·64; six-phase, 1·96. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1281. *Electric Power in Workshops.* **C. M. Barber.** (Mech. Eng. 3. pp. 159–160, 1899.)—In this paper the author briefly deals with the chief considerations bearing on the use of electromotors in place of long countershafts and belting. Overhead shafts and belts interfere with travelling cranes, and require heavy roof columns. With motor driving, each machine is self-contained, and can be put down in any desired position. The first cost of motors is greater, but the maintenance less, than with shafting. Numerous tests show that the loss in mechanical transmission varies between 10 and 80 per cent. of the power applied, the average being about 30 per cent.; the electrical loss is about 22 per cent. Smaller driving plant is needed with motors; *e.g.*, in a lithographic works the rated output of the generators was 50 per cent. of that of the motors, the maximum load 32·7 per cent., and the average load 17·6 per cent. The speed of motors is easily and economically varied between wide limits, and low-speed motors are now obtainable of all sizes; the works should, however, be designed to use high speeds wherever possible.

In the discussion, **C. H. Benjamin** stated that he found the average mechanical loss in a number of works to be about 55 per cent. **J. H. Sherwood** gave details of tests made on very heavy shafting and belting, where the loss was only 10 per cent.; in this case the bearings were carefully lined up every month.

A. H. A.

1282. *Electric Power in Workshops.* **H. A. Mavor.** (Mech. Eng. 3. pp. 234–236, and 270–271, 1899.)—The author is of opinion that electric power will never be less costly than power obtained from gas engines, though other considerations are likely to result in electricity being preferred. The rapid spread of electric traction will most probably lead to a reduction in the cost of dynamos and motors. The author classes factories into two groups, viz., those which cover a small area, and those which require power at widely scattered points. A diagram is given showing the various losses incidental to the use of shafting, as compared with electricity. In the case of the first group, the total loss between I.H.P. and useful H.P. at the machines is about 25 per cent. with either system. A diagram is also given showing, in the case of the second group, the capital and running costs for distribution by shafting, steam, and electricity, with a load factor of about 60 per cent. The initial expense is about the same in each case; the running cost of shafting is slightly less than that of electricity, but both are much less than that of steam. In preparing the diagrams, the steam consumption per I.H.P. hour was assumed to be 30 lb., but in practice the average of 100 engines in eight factories was found to be 47·7 lb. In a 120 H.P. installation known to the author, the adoption of electricity led to a saving of over 50 per cent. of the fuel previously used, or about £100 per month. The author believes direct current to be decidedly superior to polyphase currents in factories. The necessity for speed-reduction gearing is briefly dealt with. A. H. A.

1283. *New Union Station, Boston, U.S.A.* (Elect. World and Elect. Engin. N.Y. 33. pp. 297–303, 1899.)—An illustrated description of the 1,500 H.P. electrical generating plant, elevators, and signal operating devices. Signals are worked pneumatically, the valves being actuated by electro-magnets and also interlocked electrically. Induced draught is used, and a short steel stack of ⅜ inch plate and 11 feet diameter. The chief elevators are controlled by push-buttons, operating pilot motors which revolve the controllers. E. H. C.-H.

1284. *Central Power House, Boston Elevated Railway.* **H. W. Weller.** (Railway World, 8. pp. 124–131, 1899.)—This station has been erected to operate the lines of the West End Street Railway Co. The engine-room is 147 feet × 173 feet, and the boiler-room 230 feet × 86 feet. The chimney is 252 feet high by 13 feet 8 inches inside diameter. There are twenty 250 H.P. and eight 500 H.P. Babcock boilers. An electric locomotive dumps coal in front of the furnaces and removes ashes. The main damper is operated automatically. Steam piping, which is in sections and not in duplicate, is extra heavy, with copper bends, flanged joints fitted with copper gaskets, and steel fittings. A 3,000 kw. unit is being erected, and there are already running six 1,600 H.P. and two 2,000 H.P. triple-expansion condensing sets. Some of the steel-plate fly-wheels running at 80 r.p.m. are 24 feet in diameter and weigh 60 tons. Independent steam connections are provided, so that either cylinder may be disconnected, and the other operated alone at high pressure in emergencies. The switchboard is of the usual standard type, the main panel containing a 25,000 ampere Weston ammeter. E. H. C.-H.

1285. *Cleveland Electric Railway Power Station.* (Street Rly. Journ. 15 pp. 199–205, 1899.)—A 2,400 kw. 22-pole generator has recently been added. Its armature is 12 feet in diameter and 2 feet across the face, with bars of such shape that no joint occurs at the fly-wheel end. The generator weighs 180,000 lb., and has a shaft 20 inches in diameter. Its width is 270 inches, and its length along the shaft 61 inches. It is direct-coupled to a vertical cross-compound non-condensing engine running at 75 r.p.m. with

160 lb. pressure. The fly-wheel is 25 feet in diameter, and weighs 160,000 lb. The shaft is 25 feet long, with spherical bearings 4 feet long. Ten 264 H.P. B. and W. boilers are connected by 8-inch pipes to a 20-inch steam header. The coal-handling equipment is very complete, including storage capacity for 900 tons of coal. The smoke-stack is of steel lined with brick, self-supporting, and 225 feet high, with a flue 10 feet 6 inches inside diameter, while the bell-shaped base is 25 feet in diameter and anchored to the foundations. The engines are run non-condensing, because the exhaust steam is supplied to the evaporating appliances in a neighbouring salt mine. The switchboard contains an automatic circuit-breaker of 6,000 amperes capacity.

All short cars are being replaced by long bogie cars. In the motor repair shop, a dismantling appliance is used, consisting of a timber truss of the same length as the car on each side of the pits. These trusses are elevated by screws connected together with bevelled and worm gear driven by a motor, both trusses being elevated simultaneously. By placing timbers from one truss to the other under the car body, the car is elevated and held firmly in position, so that the axles and motors can rapidly be run out. A portable hydraulic device for removing armatures is also provided. The shop tools, including a Murphy wheel grinder, are driven by a 75 H.P. electric motor. E. H. C.-H.

1286. *Calculation of Power and Use of Accumulators for Electric Traction.* **L. Schröder.** (Elektrotechn. Ztschr. 20 pp. 111–115, 1899.)—The first part of the paper deals with the methods of determining the power required for a given service of cars of known weight and carrying capacity along a line of known gradients. In making this calculation the author assumes a combined efficiency of 70 per cent. for the motors and gearing, and adds 25 per cent. to the pull required to overcome friction in order to allow for starting; in the case of small plants a larger allowance must be made, since most of the cars may happen to be starting at the same time. The second part of the paper is concerned with the advantages of stationary accumulators in power stations. In order that the cells may act as efficient regulators, the generators must be shunt-wound machines with a considerable droop in their characteristic. The following rule is recommended by the author with regard to the size of the cells. For plants requiring a current not exceeding 200 amperes, the cells should be capable of standing a *charging* current equal to the normal current of the generator. For plants requiring about 600 amperes, the cells must be capable of standing a *discharge* current of this amount. For intermediate sizes of plant intermediate sizes of cells are used, the ratio of the maximum *charge* to the maximum *discharge* current being generally 3 : 5. The cells should be capable of discharging at their maximum rate for one hour. A. H.

1287. *Working Expenses of Electric and Cable Railways.* (Railway World, 8. pp. 132–133, 1899.)—Details are given of the expenses, receipts, &c., of the only three lines in England the accounts of which are available. The totals for the last half of 1898 were as follows :—

LIVERPOOL OVERHEAD ELECTRIC RAILWAY.

Expenses per train mile.	Receipts per train mile.	% of Expenses to Receipts.	Miles run.	Passengers carried.
14·92	26·12	57·12	373,560	4,894,921

CITY AND SOUTH LONDON ELECTRIC RAILWAY.

15·88	28·28	56·15	234,166	3,462,814

GLASGOW DISTRICT CABLE SUBWAY.

7·13	15·54	45·38	554,770	6,666,082

To facilitate comparison of these results, the following data are given :—

	Liverpool Overhead.	City and South London.	Glasgow Subway.
Number of cars in train	2	3	2
Passenger accommodation (seated)	114	96	66
Weight of train, empty	31 tons	31 tons	13½ tons.
Weight of train, all seats occupied	38 tons	37 tons	18 tons.
Receipts per passenger carried	2d.	1¼d.	1½d.
Length of railway (double track)	6¾ miles	3 miles.	6¾ miles.
Train miles run per double-track mile........................	55,342	78,055	82,151

From the Glasgow statistics, where single gripper cars were used in the early part of the year, and trail cars in the second half-year, it appears that an increase of 50 per cent. in the dead load of cars made no increase in total working expenses, showing the merit of cable haulage for heavy work. E. H. C.-H.

1288. *Bristol Electric Tramways.* (Railway World, 8. pp. 85–96, 1899.)—A *résumé*, brought up to date, of descriptions of the Bristol Tramways system. A return booster circuit has been added, which reduces the drop on the return from 9 volts to 3 volts. E. H. C.-H.

1289. *Rapid Transit in Cities.* **J. Lundie.** (Street Rly. Journ. 15. pp. 228–230, 1899.)—The variations in speed on any given schedule determine (*a*) the necessary weight on the driving wheels required to give sufficient adhesion for acceleration; (*b*) the power and capacity of the necessary motor equipments; (*c*) the total energy to perform the movement. The two extremes in performing any given average running speed are, (i.) accelerating up to the point of braking; (ii.) accelerating as rapidly as possible to above average speed, and then coasting or keeping this speed to the point of braking. To make a given distance in a given time with the first extreme requires the least powerful motors, but the maximum amount of energy: with the second extreme, the most powerful motors are required, but the minimum amount of energy is used. E. H. C.-H.

1290. *Tramway Permanent Way.* **W. H. Rosencrans.** (Street Rly. Rev. 9. pp. 181–183, 1899.)—Sections of the road-beds in several American cities are given. With 60-feet rails a $\frac{3}{16}$ inch space should be allowed at 50° F., or $\frac{1}{16}$ inch at 90° F. Where covered to their full depth in paved or gravelled streets, however, 60 feet rails may be laid with closed joints.

E. H. C.-H.

1291. *Tramcar Design.* **H. Mozley.** (Railway World, 8. pp. 145–146, 1899.)—The weight of electric cars makes the adoption of a power brake advisable. If an air brake is used, a sand blast arrangement might be coupled to the sand boxes to secure efficient sanding with a minimum of sand. According to a report to the American Street Railway Association at Boston, Sept. 6, 1898, upon bogey and four-wheel cars, the latter type necessitates too long a wheel base, is subject to vertical oscillations, "pounds" the track, and is insufficient for "rush-hours." The bogie car with motors on all four axles largely obviates these objections, and is operated with greater economy in wages, which is an important item, being 52 per cent. of the gross cost of working. E. H. C.-H.

1292. *Inspection of Street-Car Equipments.* **A. B. Herrick.** (Frank. Instit. Journ. 147. pp. 360–377, 1899.)—The resistance of starting rheostats often increases with age, sometimes quadrupling. The car will not then start on the first notch, but gives the "kangaroo start" on the second notch; the motors then have to carry, and the station has to supply, more current. Faulty rheostats are the real cause of many burnt-out fields which often result in burnt-out armatures and other troubles. Frequent measurements should be made of the resistances of the various circuits, including motor brushes and controller contacts, which should be carrying their normal currents. A modification of Kelvin's method is the only reliable one for these tests.

Coils should not be dried by passing current through them, because electrolysis then forms copper salts with the water or alcohol and destroys the insulation. Baking ovens should be ventilated or they act only as steam boxes. The two motors should be equal within 8 per cent.; the best test of this is the change in drop of volts across the fields (carrying the same current) on the series and parallel notches. Two-way connectors are responsible for many troubles. E. H. C.-H.

1293. *Trolley Car Mishaps.* **S. Woodfield.** (Lightning, 15. pp. 304–305, 1899.)—A recital of actual accidents to trolley cars and their equipments on the road, with hints as to immediate repairs by the motor-man. E. H. C.-H.

1294. *Accumulators for Motor Cars.* **P. Northey.** (Automotor Journal, 3. pp. 202–204, 1899.)—The Crowdus cell gave the author 10 watt-hours per lb. of complete cell at a four-hour rate, as against the corresponding figure of 7·6 watt-hours for the best of the ordinary makes. The weight of its grid is only one-third of the finished plate. The positive plates are surrounded by a cellulose jacket, which prevents the continued wash of acid against the faces. Perforated hard rubber separates the positive and negative sections. The cell plates are connected both at top and bottom corners under the level of the acid. Comparing the cost of maintenance of a horse-drawn and electrical-driven brougham, holding two persons and driver, and travelling 11,000 miles per annum, the author gives £105 10s. as the annual cost with horses, and £67 10s. with electricity. The items are: Two horses, including fodder, shoeing, and veterinary charges, £83. Depreciation at 12½ per cent. on £180 (the cost of two horses), £22 10s. 3,790 units at 3d. (allowing a 1·4 ton vehicle, to run 30 miles with one charge and an energy efficiency of 77 per cent.), £47 10s. Upkeep at 25 per cent. on the 8,000 watt-hour battery, costing £80, £20. No acid should be used without testing, as different batches from same makers vary greatly. Nitrogen compounds, arsenic, iron, copper, and hydrochloric acid are objectionable. Care must be taken against impurities introduced by corrosion of cell connections.

Discussion (pp. 204–206.)—**Oppermann** had found that cellulose envelopes would not stand sulphuric acid for long. If a battery were made costing £40 and lasting only two years, it would pay to use it on electric vehicles. E. H. C.-H.

1295. *Joel Motor Car.* (Elect. Rev. 44. pp. 543–544, 1899.)—Two comparatively slow speed motors are used, one on each hind wheel. The field magnet is centrally wound on a steel core with twelve radial pole-pieces, outside which the tunnel-wound armature built up on laminated rings, revolves. The two B.H.P. size can be worked up to three B.H.P., runs at 600 revolutions per minute, weighs 1 cwt. and gives 90 per cent. efficiency at full load. The carriage body is carried on a rectangular underframe of steel tube suspended on springs and connecting the axles together in place of the usual "perch-bar." This frame safeguards the motors from shock. The armatures carry sprockets, driving bicycle chains which drive the carriage wheels by leather-covered pulleys without sprockets. This is found efficient, convenient for turning, and capable of negotiating hills of 1 in 8. The motors are self-adjusting for turning corners. Twenty cells are carried under the driver and twenty under the back seat. The forty cells complete with boxes weigh 8 cwt. Each cell weighs 22 lb. complete, takes a normal charge of 20 amperes, and, at 20 amperes discharge rate, has a capacity of 140 ampere-hours, or 13 watt-hours per lb. of complete cell, and 17 watt-hours per lb. of plate only. At a 40 ampere rate the capacity is 120 ampere-hours. The total weight of the carriage, which carries a driver and three inside passengers, is 1 ton, and it will travel 50 miles with one charge on good ordinary roads. Slight depression of the foot-brake puts resistance in the motor circuit; further depression breaks the circuit. E. H. C.-H.

1296. *Motor Car Design.* **T. H. Parker.** (Elect. Rev. 44. pp. 481–482 and 525–526, 1899.)—Experiments with a horse drawing a brougham through a spring-balance showed that an unloaded electric car for six persons, equipped to run for three hours at 8 m.p.hr. must weigh at least 25 cwt. The author first tried two series motors at 950 revs. per min., which each gave 30 lb. torque at the periphery of the armature carrying 25 amperes. The front and back wheels were made to move simultaneously through the same angle in opposite directions, so that the car turned in its own length and all four wheels could be driven if desired. Owing to difficulties in holding the car on hills, the motors were rewound as shunt machines with surprising results. Instead of the usual rush of current (50 amperes) at starting, the car moved steadily away with less than 10 amperes, and when up to speed only took the same current as with series motors. With the controller on a given notch the speed hardly varied; on the stiffest down grades the speed did not rise 5 per cent., and 20 amperes charging current were sent into the battery. The author states that, without use of brakes or reversing motor, the car was arrested in 3 feet on a 10 per cent. grade at full speed. The motors develop two B.H.P. at 560 r.p.m. and weigh 2½ cwt. each. Special tangent wheels were used having two spokes formed by one wire; the loop formed at the hub-end is fastened by pins through the double flanges of the hubs. No reasonable strain will wrench such spokes from the hub, and the method permits hub and sprocket being cast in one piece. E. H. C.-H.

1297. *Electric Brakes as Recuperating Devices.* **F. B. Booth.** (Elect. World and Elect. Engin. N.Y. 33. pp. 435–436, 1899.)—The objection to combining the functions of electric braking and recuperation of the cells is that all the retarding force of the brake has to be transmitted through gearing which is liable to be stripped. The best form of electric brake is a mechanical shoe applied by an electromagnet energised by the motor running as a dynamo or by current from the battery when the speed decreases. It is impracticable to use the charging combination as an emergency brake; it should only be used on steep hills, and its retarding qualities should be regarded as incidental. Consider a vehicle of 2,000 lb. with pneumatic tyres; this would require 50 lb. draw-bar pull on good level roads at moderate speeds. On descending a 5 per cent. grade, gravity exerts a pull of 100 lb., or 50 lb. in excess of the pull necessary to maintain the assumed speed of 5 m.p.h. downhill. Assuming an overall efficiency of 66·5 per cent., the power returned to the batteries will be only 243 foot lb. per second, whereas to ascend the same grade requires 1,447 foot lb. per second. The energy returned will only propel the vehicle for a level distance equal to half the length of the hill descended. Curves are given showing the maximum percentage of return on different grades, proving that a recuperating device is valueless unless grades of more than 6 per cent. are frequently encountered. E. H. C.-H.

1298. *Moore's Truck.* (Street Rly. Rev. 9. pp. 178–179, 1899.)—This novel truck has been developed in Chicago City Railway Shops. It has longitudinal pine sills, $3\frac{1}{2} \times 4\frac{1}{2}$ inches, strengthened by $\frac{3}{8}$-inch steel plates on the outside. The cross-ties and motor supports are of oak. The pedestals are so arranged that the wheels can be taken out without interference with the car body. The oil boxes allow $1\frac{1}{4}$ inches play laterally in each direction. The brake-shoe hanger has a ball-and-socket attachment, to secure uniform wear of wheels. The car body rests on 16 cup-shaped rubber insulators and the absence of metallic contact between track and car body secures easy, noiseless riding. Practically no forgings are used on the truck, but only malleable iron castings. E. H. C.-H.

1299. *Breakage of Car Axles.* **J. F. Thompson.** (Street Rly. Journ. 15. pp. 211–213, 1899.)—This paper contains a number of photographic reproductions of fractures of steel axles, some of the fractures having taken place during ordinary working, and others having been made on new axles. The weakest point, where the fracture takes place, is sometimes on the outside of the wheel next to the journal, and sometimes on the inside, according to the type of motor used. Shoulders and sharp corners in steel axles should be avoided as far as possible. Iron castings stand a better physical test when they are a year or two old than immediately after casting. Observations show that where chilled cast-iron car wheels break in service, it is quite early in the life of the wheel; which seems to prove that there is no tendency to crystallise, but rather that the effect of age is to increase the strength of the iron. If this is correct as regards cast iron it would also seem reasonable with regard to hammered iron or steel. A. S.

1300. *Use of Magnets instead of Springs in Trolley Bases.* **A. Hecker.** (Zeitschr. Elektrotechn. 5. pp. 38–40, 1899.)—The trolley pole must be allowed considerable up-and-down play in cases where the height of the overhead conductor above the rails is very variable. It then not unfrequently happens that on the trolley leaving the conductor the pole strikes and breaks a number of span-wires before the car comes to rest. In order to avoid this risk, the author proposes to dispense entirely with springs in the trolley base, and to substitute for them a coil-and-plunger mechanism traversed by the main current. If the trolley should be thrown off the conductor, the excitation of the magnet ceases, and the trolley pole falls down by gravity out of harm's way. Illustrations are given showing details of the proposed arrangement. A. H.

1301. *Controlling Stray Currents on Electric Railroads.* **M. Kallmann.** (Elektrotechn. Ztschr. 20. pp. 163–171, 1899.)—In this paper there are described methods for determining the resistance of rails used as return conductors, firstly, when the sections of the line to be tested are isolated, and secondly, during working; methods for controlling the differences of pressure at the various feeding-points of the rail during working, and the differences of potential occurring between the rails and other metallic conductors in the roadway; and also methods for determining the earth currents escaping from the rails. The methods given are very fully discussed by the aid of diagrams. Reference is also made to earlier work on this subject.

C. K. F.

1302. *Rail Bonding.* (Zeitschr. Elektrotechn. 4. pp. 32–33, 1899.)—The method consists in using a supplementary copper conductor which follows the line of the track and is bonded to each length of rail. The bond itself consists of a thimble and short, flat pin which fits inside it. The thimble and pin are both perforated with circular holes lying along a diameter of the thimble (*i.e.*, at right angles to its axis). The copper conductor is passed through these holes, the thimble is inserted into a hole in the web of the rail, and the flat pin driven in with a blow from a sledge-hammer. The copper conductor—which must be of very soft copper—is thereby bent into the shape of a **U**, the two limbs of the **U** fitting into corresponding circular channels (one on each side of the flat pin) in the thimble. The latter is expanded and forced tightly against the sides of the hole in the rail. A. H.

1303. *Train Resistance.* **J. B. Blood.** (Street Rly. Journ. 15. pp. 142–145, 1899.)—The author discusses the various formulæ that have been proposed for train resistance. There are three main factors: the resistance of the journals, approximately constant at high speeds; the friction between the rail and track, which varies approximately with the speed; the wind resistance, which is independent of the weight of the train, and which varies as a power of the speed lying between the first and second. The general formula would then be—

$$R = B + WM + A\frac{M^n}{T}$$

where R, M, and T are the resistance, speed, and weight respectively of the train, B, W, and A are coefficients for the journals, rails, and air respectively, and *n* is an exponent to be determined by experiment.

To the best of the author's knowledge the formula which would represent good practice would be—

$$R = 4 + {\cdot}15M + 30\frac{M^{1{\cdot}8}}{T}.$$

Curves are shown comparing the various formulæ, from which it is seen that it is immaterial for trains weighing over 200 tons and running at less than 40 miles an hour, whether the exponent of the speed term be of the first or second power. The variation from the curves is less than the accuracy of the experiments among themselves. A. S.

1304. *Good and Bad Incandescent Lamps.* **F. W. Willcox.** (Elect. World and Elect. Engin. N.Y. 33. pp. 337–340, 1899.)—The most prominent physical defects are loose caps or bases, bad connections in base, poor vacuum, and spotted or discoloured filaments. The last defects can be detected by examination of the lamp filaments by light, when they should reveal a smooth, solid, dark grey surface, and by burning the filament at a dull red, when it should show up thoroughly uniform and free from any dark or bright spots. Batches of lamps, of which more than 10 per cent. are defective as above, should be rejected. W. G. R.

1305. *Silicon Carbide "Premier" Incandescent Lamp.* (Electrician, 42. p. 690, 1899.)—This lamp, called the "Premier," was invented by Langhans, and is now being introduced by the Premier Electric Lamp Syndicate of Liverpool. The first part of the process of manufacture consists in the treatment of cellulose in successive operations with sulphuric acid of varying concentrations, or with both sulphuric and phosphoric acids, by which means a gelatinous semi-liquid substance is obtained with which silicon, in the form of a fine amorphous powder, is incorporated. The semi-liquid mass of cellulose and silicon, after being freed from air-bubbles by rapid rotation in a centrifugal machine, is pressed or squirted through a fine aperture, from which it issues in the form of a continuous thread, which, passing through alcohol into water, hardens in the usual way. The thread is washed, wound on frames to dry, and carbonised in the ordinary manner, except that, in order to protect the silicon from any nitrogen which may be present, the forms on which the thread is wound are surrounded by a mixture of carbon powder and titanic acid; and that the highest temperature attainable must be held for a sufficient time for the silicon and the carbon formed from the cellulose to combine. The filaments are then "flashed" in a vapour of carbon and silicon.

Owing to the refractory nature of these filaments, they can be run at a higher efficiency than is possible with any carbon filament; they are also claimed to be free from falling off of the light and blackening of the bulbs as time goes on. E. C. R.

1306. *A.B.C. Arc Lamp.* (Elect. Rev. 44. pp. 198–201, 1899.) —This is a new arc lamp, and the following advantages are claimed for it: cheapness and simplicity of construction; adaptability to all circumstances and uses; total absence of mechanism; instantaneous striking of the arc; absolute steadiness of the light; impossibility of extinction; great efficiency of candle-power per unit of current; saving in carbon (45 per cent.); increase of light (20 to 30 per cent.); long burning, and consequent saving of labour.

The frame of the A.B.C. lamp is composed of two brass tubes, the extremities of which are provided with flanges of the same metal, and these are fixed to two cross-pieces. Each of these tubes is surrounded by a solenoid encased in a wrought-iron shield, which is itself closed at each end by an iron washer. Two chains run over pulleys and support at one end the upper carbon-holder, whilst the other ends of the chains are attached to the cores of the solenoids, which are rigidly attached to the lower carbon-holder. The regulation is performed by the attraction of the solenoids on their cores and by gravity. The superiority in illuminating power is produced by the addition of a mantle which is rendered incandescent by the arc. The mantle is said to be unalterable, and to resist the highest temperatures.

W. G. R.

1307. *A 95-Volt Arc Lamp.* **A. D. Adams.** (Elect. Engin. N.Y. 27. p. 222, 1899.)—In a form of enclosed arc lamp working on 110-volt mains at the Boylston Café, Boston, Mass., U.S.A., the regulating coils are shunted by an induction coil. This causes every change in pressure and current at the arc to be opposed by the inductive action of the coil. Thus a much larger percentage of the line pressure is available at the arc, which in this lamp burns regularly at 95 volts. Comparative tests of this lamp and an enclosed arc lamp working with 78 volts at the arc, gave the following results :—

	Long Arc.	Short Arc.
Volts at main	110·	110·
Volts at arc	95·3	78·1
Amperes	4·19	4·12
Watts to lamp	461·	452·
Watts to arc	398·	322·
Mean spherical C.P.	128·	91·3
Watts per spherical C.P. lamp	3·59	4·96
Watts per spherical C.P. arc	3·11	3·50

Gain in efficiency in lamp.............. 27 per cent.
Gain in efficiency in arc.................. 11 per cent.
One spherical C.P. cost 27 per cent. less from the mains.
One watt taken by lamp will give 35 per cent. more light.

C. K. F.

1308. *Volta Arc Lamps.* **W. Wedding.** (Elektrotechn. Ztschr. 20. pp. 65–69, 1899.)—Volta lamps can be worked three in series on 110-volt circuits. Curves and tables are given showing the distribution of the light and comparative cost of working. No particulars are given of the construction of the lamp

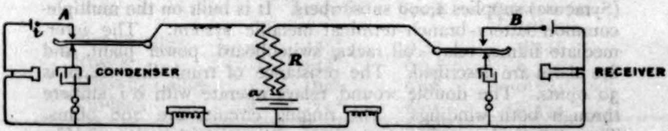
C. K. F.

TELEGRAPHY AND TELEPHONY.

1309. *Rowland's Multiplex Printing-Telegraph.* (Elect. Engin. N.Y. 27. pp. 248–249, 1899.)—The apparatus is intended for eight simultaneous messages—four each way—when the instruments are duplexed. Trials were made on an artificial cable, equivalent in resistance and capacity to 1,500 miles of *land-line*, of total capacity 23 microfarads. Photographs of the sending and receiving instruments are given in the article, but further description is reserved. R. A.

1310. *Bell's Selenium Transmitter.* (Elect. Engin. N.Y. 27. p. 223, 1899.)—The voice causes a balance-arm to vary a resistance in series with a low resistance glow-lamp at a red heat. A strip of selenium is illumined by this lamp and is in series with a battery and the line. M. O'G.

1311. *Centralised Sources of Energy in Telephone Exchanges.* **K. B. Miller.** (Elect. World, 33. pp. 178–179, 1899.)—The system of H. V. Hayes of the American Bell Co. in 1892, which is rapidly spreading, is described:—



It will be seen from the figure that fluctuations in the transmitter B affect the coil R and act inductively on the circuit of transmitter A. Stone's method, involving a secondary cell at each subscriber station, is described. H. M. Crane's cord circuit relay is described and the credit of the development of these methods ascribed to the engineers of the Bell and Western Electric Co. (See 1899, Abstract No. 972.) M. O'G.

1312. *Weber's Telephone Call-Check.* (Elekt. Runds. 16. pp. 105–106, 1899.)—This apparatus (German Patent 98857), due to R. Weber, is intended to put a time-limit on the users of telephones at public call-offices, and to indicate the number of such periods taken up by a user. It is arranged so that an unanswered "call" is not recorded. The apparatus consists of clockwork actuated by a toothed-quadrant to which motion is communicated by a falling rod. In its normal position the rod is held down by the weight of the telephone. When the telephone is removed from its hook, the rod begins to be drawn up by a spring, the toothed quadrant comes into gear with the clock work, and the motion is recorded on a dial. If the telephone is replaced before the last tooth of the quadrant has been reached, no permanent record is made; the period is adjusted so as to be long enough for a subscriber to "get on," but not long enough for conversation. When the telephone is kept off the hook for a longer period, the electrical connections are automatically thrown off by the quadrant, and each resetting of them is indicated.

R. A.

1313. *Scribner's Telephone Connection Counter.* (Elect. Engin. N.Y. 27. pp. 108–109, 1899.)—Each telephone line is provided with an answering jack and a line jack. The counter only operates in response to the call at the called substation through the agency of the registering contact pieces of the answering plug and answering jack only. Details of connections are given.

The system is due to C. E. Scribner. M. O'G.

1314. *New York Telephones.* **M. Loewenthal.** (Elect. Engin. N.Y. 27. pp. 142–147, 1899.)—The rent for unlimited distant service is from £7 16s. to £16. The new Exchange (Syracuse) supplies 2,000 subscribers. It is built on the multiple-common-battery-branch-terminal-metallic system. The intermediate frame, relay coil racks, switchboard, power plant, and fire alarm are described. The resistance of trunk line relays is 30 ohms. The double wound relays operate with 0·1 ampere through both windings. The ringing circuits are 200 ohms. The operator's set has 600 ohms, the capacities are 2 mfds. each. There are besides three toll and distance boards. The time of a conversation is recorded on calculagraphs previously described. M. O'G.